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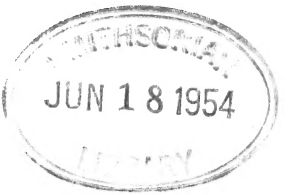
The Quarterly Journal *of* The Florida Academy of Sciences

A Journal of Scientific Investigation and Research

H. K. WALLACE, *Editor*

VOLUME 13



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VOL. 13 1950 Nos. 1-4

QUARTERLY JOURNAL OF THE FLORIDA ACADEMY OF SCIENCES

A Journal of Scientific Investigation and Research

Communications for the editor and all manuscripts should be addressed to H. K. Wallace, *Editor,* Department of Biology, University of Florida, Gainesville, Florida. Business communications should be addressed to Chester S. Nielsen, *Secretary-Treasurer,* Florida State University, Tallahassee, Florida. All exchanges and communications regarding exchanges should be sent to the Florida Academy of Sciences, Exchange Library, Department of Biology, University of Florida, Gainesville.

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PREFACE

During the recent war the Journal fell one whole number behind in its publication schedule. Due to a shortage of funds it would have been impossible to come up to date without outside help. At the Council Meeting in Lakeland on March 11, 1950 the Secretary-Treasurer, Dr. C. S. Nielsen, on behalf of the Florida State University, made the Academy the following offer:

A number of papers presented at the December, 1949, meetings in DeLand by members of the staff of Florida State University would be gathered together and published as the first in a projected *Florida State University Series.* The Academy would be permitted to purchase copies of this volume at cost, and, with appropriate covers and acknowledgements, distribute them as a volume of the Quarterly Journal of the Florida Academy of Sciences; thus enabling the Academy to come up to date with its Journal at a considerable saving.

The Council voted to accept this offer and Volume 13, the present volume, is the result. All of the editorial work for this volume was handled by the following officers of the Florida State University Studies: *Editorial Committee*—J. P. Stokes (Chairman), Milton W. Carothers, Louis Shores, Marian Irish, Lyman D. Toulmin; *Editors*—William Randel, Weymouth T. Jordan, Lyman D. Toulmin.

H. K. W.

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VOLUME ONE—NUMBER ONE

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FLORIDA STATE UNIVERSITY STUDIES

EDITORIAL COMMITTEE

J. P. Stoakes, *Chairman*

Milton W. Carothers
Marian Irish
Louis Shores
Lyman D. Toulmin

EDITORS

William Randel
Weymouth T. Jordan
Lyman D. Toulmin

Price: One Dollar

PREFACE

The Florida State University Studies, established early in 1950 under the auspices of the Research Council, were conceived as a means of providing publication for the rapidly increasing research being conducted on this campus. An Editorial Committee, appointed by the President and responsible to the Research Council, has designated editors representing three major areas—science, social studies, humanities—and has planned quarterly issues of more or less homogeneous material.

This first issue includes several papers on botanical subjects and one each in mathematics and marine biology. In addition are two studies related to science, one on the mathematics needs of science students, the other on the scientific knowledge students possess when they enter an integrated course in physical science. Other science departments at Florida State University, such as bacteriology, chemistry, geology, physics, and zoology, are currently active in research and will be represented in subsequent issues.

The papers here assembled were all written by members of the Florida Academy, which, under its own cover, is using this as an "overflow" issue in its own series. Dr. Chester S. Nielsen of the University's Department of Botany has served in a liaison capacity between the Academy and the Studies. Dr. Toulmin, as editor representing the science area, has been chiefly responsible for the examination of manuscripts, the reading of proof, and the last-minute details that editorship entails.

W. R.

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FLORIDA STATE UNIVERSITY STUDIES

VOLUME ONE — NUMBER ONE

PHOTOPERIODIC RESPONSE IN CREPIS[1]

Grace C. Madsen and C. S. Nielsen

The genus *Crepis* has been the subject of an intensive investigation by Ernest Brown Babcock and his colleagues of the Division of Genetics, University of California. In 1915 the published works of Rosenberg (1909), Digby (1914), and Juel (1905) on low chromosome counts in *C. capillaris* and *C. tectorum* suggested a program of research paralleling that of Morgan's on *Drosophila.*

The *Crepis* investigation begun in 1915 culminated in a monumental two-volume monograph, *The Genus Crepis,* in 1947. The earliest studies extending from 1915 to 1922 were on interspecific hybridization. Those following, 1923 to 1942, were taxonomic and were made possible by extensive collecting trips over the world. Concepts of the phylogeny of the genus based upon comparative morphology resulted from this period of study.

Concurrent with these two periods of investigations on hybridization and classification was the reseach done on chromosome number and chromosome morphology from 1918 to 1942. In 1923 it was suggested to the authors that a genetic and cyto-genetic approach might be a means of strengthening the proposed taxonomic relationship within the genus. This line of investigation was carried on until 1942, part of which time Dr. Babcock worked with Dr. Navashin.

The collected data on classification and geographical distribution have provided bases for tenable theories concerning the origin, migrations, and evolution of species in this genus. Babcock's extensive investigations serve as a pattern for the study of other taxonomic groups.

Since the first reports of photoperiodic response by Garner and Allard in 1920 it has become increasingly apparent that many of the problems of sterility, distribution, and migrations are correlated with plant reproduction as influenced by length of day. This aspect has

[1] Contribution No. 35, Botanical Laboratory, Florida State University.

been considered only indirectly by the investigators of *Crepis*. It is the intention of the authors to survey the available species of *Crepis* in order to determine their individual photoperiodic response and so to provide additional data on this well-studied genus. For this purpose seeds of a number of species were supplied by Dr. Babcock.

Of those successfully germinated, plants were divided into two experimental lots. Half the individuals of each species was subjected to continuous long day treatment of from 18 to 24 hours of light. Natural light was supplemented by mazda illumination. The second lot of plants of each species was subjected to identical conditions, except for short day cycles of approximately eight hours of light. The length of time required to bloom under continuous long day varied considerably with the species. Some forms such as *C. tectorum* bloomed within four weeks of germination. Others as *divaricata* and *neglecta* required as much as ninety days. The following eleven species:

divaricata (Lowe) F. Schultz
neglecta L.
palaestina (Boiss.) Bornm.
parviflora Desf.
pulchra typica Babc.
sancta bifida (Vis.) Thell.
senecioides L.
setosa typica Babc.
suberostris typica Coss. et Durieu
tectorum L.
zacintha (L.) Babc.

flowered under the long day treatment. All the plants of these eleven species in Lot II, which was exposed to short day treatment, remained vegetative and retained the rosette habit.

Other species in these preliminary experiments remained vegetative under both long and short cycles of light. Some are reported to be biennial or perennial. Still other species bloomed under both conditions. During the course of these experiments temperature varied from a low of 40° to a high of 94° F. in the greenhouse. It is well known that certain plants under normal conditions are markedly sensitive to the photoperiod, but can be induced to bloom by relatively short but sustained periods of higher temperature. These problems in addition to the degree of photoperiodic sensitivity and possible thermo-induction are the subjects of present investigations.

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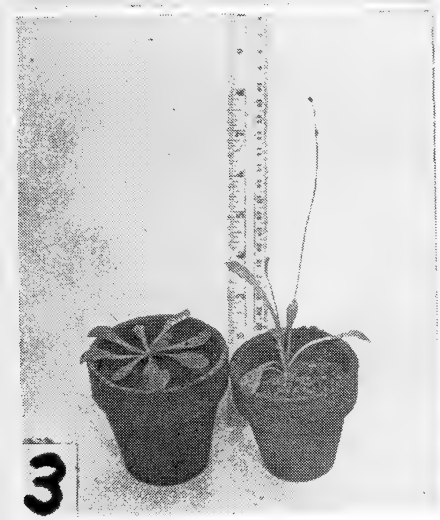
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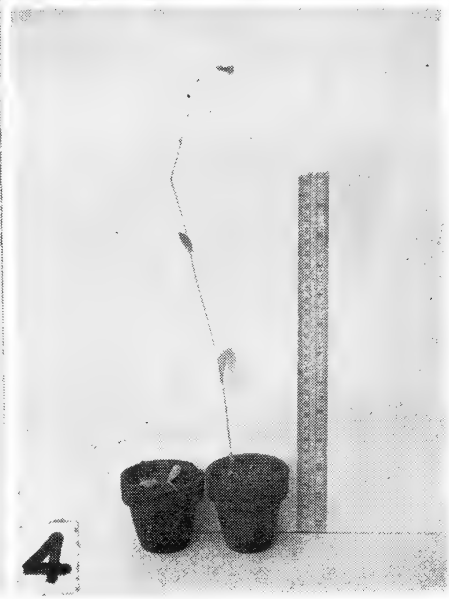
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CHECK LIST OF THE ALGAE OF NORTHERN FLORIDA II[1]

Grace C. Madsen and C. S. Nielsen

In February 1948, the authors began a systematic survey of the algal flora of the northern area of Florida. To the authors' knowledge this type of study has not been made before of this region. The first check list of algae included 102 specimens collected from February 1, 1948, to July 1, 1948, in Leon, Wakulla, Jefferson, and Gadsden counties.[2] The second check list of 44 species obtained from July 1, 1948, to December 15, 1948, was from Leon, Wakulla, Calhoun, Jackson, Washington, Liberty, Polk, and Pinellas counties.[3]

The collections for the present report were made from January 1, 1949, to April 1, 1949, in seventeen northern counties and comprised a list of 117 species. Collecting was done by the authors, together with Dr. Francis Drouet of the Chicago Natural History Museum, and Miss Dorothy Crowson of the Florida State University Department of Botany. Specimens of each collection are deposited in the cryptogamic herbaria of the Florida State University and the Chicago Natural Museum.

CHROOCOCCACEAE

Coccochloris elabens (Breb.) Dr. and Daily

Okaloosa County, (10645), Wet sand in the outlet of a sewer into Santa Rosa Sound, at the west end of the bridge on U. S. 98, Ft. Walton.

Coccochloris Peniocystis (Kutz.) Dr. and Daily

Jackson County, (10384), On wet limestone about the entrance to the cave, Florida Caverns State Park, three miles north of Marianna.

Gleocapsa minuta (Kutz.) Hollerb.

Leon County, (10453), Wet sand in greenhouse, Florida State University, Tallahassee.

[1] Contribution No. 34, Botanical Laboratory, Florida State University.

[2] "Preliminary Check List of the Algae of the Tallahassee Area," *Quarterly Journal of the Florida Academy of Sciences*, XI, No. 4, 1948.

[3] "Check List of the Algae of Northern Florida I," *Quarterly Journal of the Florida Academy of Sciences*, XI, Nos. 2-3, 1948.

Gomphosphaeria aponima (Kutz.)

Wakulla County, (11771), Among diatoms on a tidal flat along East River about one mile northeast of St. Marks Lighthouse, on the Gulf of Mexico at the mouth of St. Marks River.

CHAMAESIPHONACEAE

Entophysalis conferta (Kutz.) Dr. and Daily

Levy County, (11181), On *Bostrychia* sp., intertidal at the east end of the bridge on the Causeway from the mainland to Way Key, Cedar Keys.

Entophysalis deusta (Menegh.) Dr. and Daily

Okaloosa County, (10637), On a stump in Choctawhatchee Bay at the east end of Santa Rosa Island.

Levy County, (11193), Intertidal on the northwest shore of Goose Cove, Way Key, Cedar Keys.

Escambia County, (10619a), Intertidal on shells, shore of Pensacola Bay, north of Bay Bridge, U. S. 98, Pensacola.

Franklin County, (10973), Intertidal on the north shore of St. Vincent's Sound about ten miles west of Apalachicola.

Bay county, (10927), In shallow water of St. Andrews Bay at the west end of Hathaway Bridge west of Panama City.

Taylor County, (11231), Between tide limits on the shore of the Steinhatchee River in the southern part of Steinhatchee.

Gulf County, (10964a), Intertidal on shells on the shore of St. Joseph Bay in the municipal park, Port St. Joe.

STIGONEMATACEAE

Mastigocoleus testarum B. & F.

Franklin County, (10968), Between tide limits at the docks in New River, Carrabelle.

Wakulla County, (11461a), In shells in shallow water, St. Marks River, Port Leon.

Stigonema panniforme B. & F.

Leon County, (11262), On an eroded clay bank beside Meridian Road between Lake Iamonia and the Ochlockonee River.

Calhoun County, (10715), Barren ground on a high boggy prairie beside state highway 20, about three miles west of Blountstown.

Santa Rosa County, (10601), On wet sand in the dunes east of Pensacola Bay.
Escambia County, (10537), In a pool behind the sand dunes, Gulf Beach.
Gadsden County, (10416), On a clay bank in upland woods beside U. S. 90, four miles east of Quincy.
Wakulla County, (10840), Barren ground on the shore of "T-pond", part of Lake Phillips, in St. Marks National Wildlife Refuge, one-fourth mile east of Port Leon.

NOSTOCACEAE

Anabaena inequalis B. & F.

Wakulla County, (11526), At Wakulla River at U. S. 319 in shallow water of riverside.

Cylindrospermun catenatum B. & F.

Leon County, (11261a), On mud by the overflow-channel beside Meridian Road between Lake Iamonia and the Ochlockonee River.

Cylindrospermun muscicola B. & F.

Leon County, (11244), On wet ground beside the drain between Ochlockonee River and Lake Iamonia.
Taylor County, (10759), Wet ground along the creek beside U. S. 27, one mile northwest of Perry.

Nodularia Harveyana B. & F.

Taylor County, (11232), Between tide limits on the shore of the Steinhatchee River in the southern part of Steinhatchee.
Franklin County, (11681), Intertidal on sand, shore of Alligator Bay east of St. Teresa.
Wakulla County, (11511), In shallow water of Wakulla River at U. S. 319.

Nostoc commune B. & F.

Levy County, (11214), In a grassy glade beside state highway 345 about two miles west of Chiefland.

Nostoc microscopicum B. & F.

Leon County, (11322), On the walls of "Natural Well," a sinkhole in limestone about one mile southeast of Woodville.

RIVULARIACEAE

Amphithrix violacea B. & F.

Franklin County, (1564), East end of John Gorrie Causeway, west of Eastport.
Franklin County, (10948b), On large plants between tide limits in New River at the bridge on U. S. 319 between Carrabelle and Carrabelle Beach.
Okaloosa County, (10637), On a stump in Choctawhatchee Bay at east end of Santa Rosa Island.

Calothrix confervicola B. & F.

Bay County, (10941a), Washed ashore in St. Andrews Bay at Frankfort St. and Beach Drive, St. Andrews, Panama City.
Bay County, (11596a), On *Gracilaria* sp. washed ashore in St. Andrews Bay, Cove Hotel, Panama City.

Calothrix crustacea B. & F.

Bay County, (10918), Intertidal on the jetty in St. Andrews Bay at Frankfort St. and Beach Drive, St. Andrews, Panama City.
Wakulla County, (11761), St. Marks Lighthouse on Gulf of Mexico at mouth of St. Marks River.

Calothrix scopulorum B. & F.

Wakulla County, (11461), In shallow water St. Marks River, Port Leon.
Franklin County, (10963), On pilings between tide limits, at docks in New River, Carrabelle.
Wakulla County, (11760), Intertidal on rocks of the jetty west of St. Marks Lighthouse on the Gulf of Mexico at mouth of the St. Marks River.
Wakulla County, (11738), On intertidal stones on east shore of East River, west of St. Marks Lighthouse on the Gulf of Mexico at the mouth of the St. Marks River.

Rivularia nitida B. & F.

Bay County, (10871), At and above high tide mark on the shore of the west arm of St. Andrews Bay, West Bay.

SCYTONEMATACEAE

Fremyella grisea B. & F. J. DeToni

Wakulla County, (11458a), On pilings in St. Marks River, Port Leon.

Plectonema nor wegicum Gom.

Levy County, (11183), Intertidal on pilings at the east end of the bridge on the causeway from the mainland to Way Key, Cedar Keys.

Plectonema Wollei Gom.

Wakulla County, (11492), In shallow water, southside of the spring-pool, Wakulla Springs.

OSCILLATORIACEAE

Hydrocoleum lyngbyaceum Gom.

Levy County, (1122), On pilings at the municipal wharf, Cedar Keys.

Lyngbya confervoides Gom.

Levy County, (11142), Intertidal on pilings on the shore opposite the municipal wharf, Cedar Keys.

Okaloosa County, (10643), Intertidal on pilings in Santa Rosa Sound, at the west end of the bridge on U. S. 98, Fort Walton.

Bay County, (10916), Intertidal on the stone jetty in St. Andrews Bay at Frankfort Street and Beach Drive, St. Andrews, Panama City.

Taylor County, (11229), On pilings between tide limits on the shore of the Steinhatchee River in the southern part of Steinhatchee.

Wakulla County, (11454), Intertidal, St. Marks River, Port Leon.

Lyngbya gracilis Gom.

Bay County, (1570), St. Andrews Bay, east of St. Andrews.

Lyngbya lutea Gom.

Franklin County, (10981), Intertidal on wood on the north shore on St. Vincent's Sound about ten miles west of Apalachicola.

Okaloosa County, (10633), Intertidal on pilings on Choctawhatchee Bay at the east end of Santa Rosa Island.

Bay County, (10878), Intertidal on woodwork in the west arm of St. Andrews Bay, West Bay.

Wakulla County, (11461b), On shells in shallow water, St. Marks River, Port Leon.

Microcoleus chthonoplastes Gom.

Levy County, (11149), Intertidal on the shore of a cove in the northwestern part of Way Key, Cedar Keys.

Taylor County, (11221), Intertidal at the confluence of Daughter Creek and the Steinhatchee River.

Bay County, (10858), Above high-tide mark on the shore of the west arm of St. Andrews Bay, West Bay.

Wakulla County, (11441), Barren ground in a lane near St. Marks River, Port Leon.

Franklin County, (11005), Intertidal on the shore of Apalachicola Bay in the southeast part of Apalachicola.

Microcoleus tenerrimus Gom.

Franklin County, (10993), Intertidal on the shore of Apalachicola Bay in the southeast part of Apalachicola.

Bay County, (11609b), Intertidal on pilings in St. Andrews Bay, Cove Hotel, Panama City.

Gulf County, (10937), Intertidal on rocks on the shore of St. Joseph Bay at the mouth of a tidal stream in the south part of Hiland View, north of Port St. Joe.

Taylor County, (11223), Intertidal at the confluence of Daughter Creek and the Steinhatchee River, Steinhatchee.

Levy County, (11154), Intertidal on pilings in a cove, northwest part of Way Key, Cedar Keys.

Wakulla County, (11456), Intertidal on rocks in St. Marks River, Port Leon.

Oscillatoria amoena Gom.

Franklin County, (1020), Wilson's Beach, Alligator Harbor.

Oscillatoria articulata Gardn.

Wakulla County, (11359), In a small sulphur spring one-half mile north of New Port.

Oscillatoria Bonnemaisonii Gom.

Taylor County, (11242), Between tide limits on the shore of the Steinhatchee River in the southern part of Steinhatchee.

Oscillatoria brevis var. neapolitana Gom.

Taylor County, (11233), Between tide limits on the shore of the Steinhatchee River in the southern part of Steinhatchee.

Oscillatoria brevis Gom.

Levy County, (11134), Intertidal on pilings near the shore, opposite the municipal wharf, Cedar Keys.

Oscillatoria corallinae Gom.

Taylor County, (11240), Between tide limits on the shore of the Steinhatchee River in the southern part of Steinhatchee.

Oscillatoria laetevirens Gom.

Taylor County, (11242), Between tide limits on the shore of the Steinhatchee River in the southern part of Steinhatchee.

Oscillatoria margaritifera Gom.

Taylor County, (11242), Between tide limits on the shore of the Steinhatchee River in the southern part of Steinhatchee.
Levy County, (11156), In a tide-pool, shore of cove in the northwest part of Way Key, Cedar Keys.

Oscillatoria nigro-viridis Gom.

Levy County, (11179), Intertidal on woodwork at the bridge on the Causeway between the mainland and Way Key, Cedar Keys.
Franklin County, (10982a), Intertidal, north shore of St. Vincent's Sound, about ten miles west of Apalachicola.
Wakulla County, (11770), On tidal mud-flats in the salt marsh east of the East River, about one mile northeast of St. Marks Lighthouse, on the Gulf of Mexico at the mouth of the St. Marks River.

Oscillatoria sancta Gom.

Wakulla County, (11487), In running water, southside of the spring-pool, Wakulla Springs.
Wakulla County, (10814), In a pool beside St. Marks River, New Port.

Phormidium submembranaceum Gom.

Levy County, (11111), Intertidal on woodwork of the Municipal Wharf, Cedar Keys.

Porphyrosiphon fuscus Gom.

Escambia County, (10532), In a fresh water pool behind the dunes, Gulf Beach.

Schizothrix conaceae Gom.

Jackson County, (10374), On limestone walls of the entrance to the cave, Florida Caverns State Park, three miles north of Marianna.

Schizothrix Heufleri Gom.

Wakulla County, (11499), On the bark of a tree, south side of the spring-pool, Wakulla Springs.

Schizothrix Lamyi Gom.

Calhoun County, (10723), Barren ground in a high boggy prairie beside state highway 20, about three miles west of Blountstown.
Escambia County, (10547), In a fresh water swale behind the dunes, Gulf Beach.
Leon County, (11262), On an eroded clay bank beside Meridian Road between Lake Iamonia and the Ochlockonee River.
Walton County, (10667), Barren ground in upland pine woods beside U. S. 98, five miles west of Walton-Bay County line, east of Sargeant Bay.

Schizothrix lardacea Gom.

Wakulla County, (11349), On concrete-work of the bathing pool near a small sulphur spring, one-half mile north of New Port.

Schizothrix longiarticulata Gardn.

Santa Rosa County, (10596), In a depression in sand dunes, Pensacola Beach.

Schizothrix roseola (Gardn.) Dr.

Gadsden County, (10430), On an eroded bank in upland woods beside U. S. 90, four miles east of Quincy.

Schizothrix Stricklandii Dr.

Wakulla County, (10796), Barren ground in the road at St. Marks River, New Port.

Symploca atlantica Gom.

Taylor County, (11217), Intertidal at the confluence of Daughter Creek and the Steinhatchee River, Steinhatchee.

Levy County, (11115), Between tide marks on woodwork at the municipal dock, Cedar Keys.

Franklin County, (10966), Between tide limits at the docks in New River, Carrabelle.

Bay County, (11615), Intertidal on barnacles on pilings on the shore of St. Andrews Bay, Cove Hotel, Panama City.

Symploca Kieneri Dr.

Levy County, (11173), An upland sand barrens northwest part of Way Key, Cedar Keys.

Wakulla County, (11743), On the eroded high bank of East River, west of St. Marks Lighthouse, on the Gulf of Mexico at the mouth of the St. Marks River.

Escambia County, (10556), On wet sand in a depression in the dunes west of Gulf Beach.

Bay County, (11633), In a depression in sand in pine woods beside U. S. 319 about five miles northwest of Beacon Hill.

Symploca laeti-viridis Gom.

Escambia County, (10549), Intertidal on the shore of a bayou near Fort Barrancas.

Wakulla County, (11735a), On intertidal stones on the east shore of East River, west of St. Marks Lighthouse on the Gulf of Mexico at the mouth of the St. Marks River.

PALMELIACEAE

Gloeocystis Nag. sp.

Leon County, (11407), Wet ground on the west shore of Six-Mile Pond beside U. S. 319, in Apalachicola National Forest, north of Woodville.

Leon County, (11538), Wet sand at cypress swamps beside State Highway 61, just north of Leon-Wakulla county line.

TETRASPORACEAE

Schizochlamys aurantia (Ag.) Dr. and Daily

Bay County, (10898), In a ditch beside state Highway 79 about four miles south of West Bay.

Taylor County, (10777), Floating in a creek beside U. S. 27, sixteen miles northwest of Perry.

ULOTRICHACEAE

Stichococcus marinus (Wille) Haz.

Escambia County, (10617), Intertidal on the shore of Pensacola Bay north of the Bay-bridge on U. S. 98, Pensacola.

Gulf County, (11644), In a tidal stream entering St. Joseph Bay on U. S. 319 north of the road to Constitution Park, Port St. Joe.

Franklin County, (10968), Between tide limits at the docks in New River, Carrabelle.

Levy County, (11178), Intertidal at the northwest shore of Goose Cove, Way Key, Cedar Keys.

Taylor County, (11219), Intertidal at the confluence of the Daughter Creek and the Steinhatchee River.

CHAETOPHORACEAE

Microthamnion Kuetzingianum Nag.

Wakulla County, (11560), Floating in shallow water of a cypress swamp beside state highway 61 east of Bethel.

CLADOPHORACEAE

Chaetomorpha brachygona Harv.

Levy County, (11174), Intertidal on the northwest shore of Goose Cove, Way Key, Cedar Keys.

Chaetomorpha Linum (O. F. Mull.) Kutz.

Lee County, (986), Fort Myers Beach.

Cladophora glomerata (L.) Kutz.

Wakulla County, (11489), Near the surface of the water at the diving pier, south side of the spring pool, Wakulla Springs.

Cladophora pithophoroides Phinney

Wakulla County, (11378), Large sulphur spring bathing pool about one mile north of New Port.

Rhizoclonium fontanum Kutz.

Wakulla County, (11363), In the stream from a small sulphur spring one-half mile north of New Port.

Wakulla County, (11400c), On stones in the outlet of a large sulphur spring bathing pool about one mile north of New Port.

ULVACEAE

Enteromorpha flexuosa (Wulf.) J. Ag.

Levy County, (1144), Intertidal on the shore, opposite the municipal wharf, Cedar Keys.
Franklin County, (1049), Lighthouse Point on Alligator Point.
Franklin County, (1027), Wilson's Beach, Alligator Harbor.
Franklin County, (11700), Intertidal on the shore of St. George Sound, half way between Eastpoint and Carrabelle.

Enteromorpha Link sp.

Franklin County, (11726), Washed up on the south shore of Ochlockonee Bay at the bridge on the state highway 30, south of Panacea.
Taylor County, (1592), Deakle Beach, south of Adams Beach.
Franklin County, (1028), Wilson's Beach, Alligator Harbor.
Levy County, (11178), Intertidal on shell on the northwest shore of Goose Cove, Way Key, Cedar Keys.
Wakulla County, (11785a), Washed up on the stone jetty west of St. Marks Lighthouse, on the Gulf of Mexico, at the mouth of St. Marks River.
Franklin County, (10980a), Intertidal on the north shore of St. Vincent's Sound, about ten miles west of Apalachicola.

Enteromorpha prolifera (O. F. Mull.) J. Ag.

Gulf County, (10934), Intertidal on the shore of St. Joseph's Bay at the mouth of a tidal stream in the south part of Highland View north of Port St. Joe.
Bay County, (11602), Intertidal on barnacles, St. Andrews Bay, Cove Hotel, Panama City.

Enteromorpha salina Kutz.

Bay County, (11612), Intertidal on woodwork in St. Andrews Bay, Cove Hotel, Panama City.

Enteromorpha salina var. polyclados Kutz.

Wakulla County, (11730), St. Marks Lighthouse, on the Gulf of Mexico at the mouth of the St. Marks River.

Monostroma latissimum (Kutz.) Wittr.

Levy County, (11135), Intertidal on Mangrove roots on the shore, opposite the municipal wharf, Cedar Keys.

Franklin County, (10964), On woodwork between tide limits at the docks, New River, Carrabelle.

Bay County, (10874), Intertidal on stakes at the bridge across the west arm of St. Andrews Bay, West Bay.

Okaloosa County, (10654a), Intertidal on pilings in Santa Rosa Sound, at the west end of the bridge on U. S. 98, Fort Walton.

SCHIZOMERIDACEAE

Schizomeris Leibleinii Kutz.

Bay County, (10921), On wood in a fresh water ditch entering St. Andrews Bay at Frankfort Street and Beach Drive, St. Andrews, Panama City.

CHARACIACEAE

Characium heteromorphum (Reinch) Wolle

Leon County, (10453), Wet sand in greenhouse, Florida State University, Tallahassee.

OOCYSTACEAE

Gloeotaenium Loitlesbergerianum Hansg.

Levy County, (11211), Floating in bog-pools beside state highway 345, about ten miles south of Jenny.

Scenedesmus dimorphus (Turp.) Kutz.

Wakulla County, (11527), Wet sand beside Wakulla River at U. S. 319.

Scenedesmus incrassatulus Bohl.

Franklin County, (1019), Wilson's Beach, Alligator Harbor.

CAULERPACEAE

Caulerpa Lamx. sp.

Pinellas County, (1511), Tides Beach, St. Petersburg.

VAUCHERIACEAE

Vaucheria geminata (Vauch.) DC.

Wakulla County, (11437), In a drying ditch near St. Marks River, Port Leon.

Wakulla County, (11519), On wet sand beside Wakulla River at U. S. 319, Riverside.

Vaucheria terestris (Vauch.) DC.

Leon County, (10459), On cultivated ground near the greenhouse, Florida State University, Tallahassee.

Taylor County, (10753), On wet ground along a stream beside U. S. 27, one mile northwest of Perry.

Wakulla County, (11449), Wet ground in a ditch near St. Marks River, Port Leon.

Vaucheria Thuretii Woron.

Levy County, (11148), Intertidal on the shore of a cove in the northwestern part of Way Key, Cedar Keys.

DASYCLADACEAE

Acetabulum Farlowii (Solms) Howe

Bay County, (1546), South end of DuPont Bridge at San Blas.

Taylor County, (1582), Keaton's Beach.

Bay County, (1609), Lighthouse Point on Alligator Point.

Batophora Oerstedii var. occidentalis (Harv.) Howe.

Taylor County, (1557), Adams Beach.

CHARACEAE

Chara Braunii Gmel. (Det. F. K. Daily)

Wakulla County, (11387), In a large sulphur spring bathing pool about one mile north of New Port.

MESOTAENIACEAE

Cylindrocystis Brebissonii Menegh.

Wakulla County, (11484), Emergent sand on the south side of the spring pool, Wakulla Springs.

Bay County, (10922), In fresh water in a ditch entering St. Andrews Bay at Frankfort Street and Beach Drive, St. Andrews, Panama City.

Franklin County, (1016), Wilson's Beach, Alligator Harbor.

Netrium digitus (Ehrenb.) Itzigs and Rothe.

Bay County, (10895), Floating in a ditch beside state highway 79 about four miles south of West Bay.

Liberty County, (10683), In a stream in woods beside state highway 20, about two miles west of Hosford.

ZYGNEMATACEAE

Sirogonium sticticum (Engl. Bot.) Kutz.

Wakulla County, (10799), On bases of trees in St. Marks River, New Port.

DESMIDIACEAE

Closterium acerosum (Shrank) Ehrenb.

Wakulla County, (11355), Among the algae in a small sulphur spring one-half mile north of New Port.

Wakulla County, (11380), In the outlet of a large sulphur spring bathing pool about one mile north of New Port.

Closterium Ehrenbergii Menegh.

Wakulla County, (11355), In a small sulphur spring one-half mile north of New Port.

Closterium intermedium Ralfs.

Bay County, (10895), Floating in a ditch beside state highway 79 about four miles south of West Bay.

Liberty County, (10687), In a stream in woods beside state highway 20 about two miles west of Hosford.

Closterium Cynthia DeNot.

Liberty County, (10689), In a stream in woods beside state highway 20 about two miles west of Hosford.

Closterium moniliferum (Bary.) Ehrenb.

Wakulla County, (11381), In the outlet of a large sulphur spring bathing pool about one mile north of New Port.

Closterium ulna Focke.

Bay County, (10890), In a roadside ditch along state highway 79 about four miles south of West Bay.

Euastrum Ehrebergii sp.

Wakulla County, (11559), In shallow water of a cypress swamp beside state highway 61, east of Bethel.

Onychonema laeve Nordst.

Taylor County, (10766), In a creek beside U. S. 27, seven miles northwest of Perry.

Pleurotaenium maximum (Reinsh.) Lundell.

Leon County, (11424), In shallow water, west shore of Six-Mile Pond beside U. S. 319, in Apalachicola National Forest, north of Woodville.

Tetmemoris Brebissonii (Menegh.) Ralfs.

Taylor County, (10761), In a creek in a cypress swamp beside U. S. 27, seven miles northwest of Perry.

OPHIOCYTIACEAE

Ophiocytium cochleare (Eichw.) A. Br.

Franklin County, (11682), In a fresh water stream, shore of Alligator Bay, east of St. Teresa.

TRIBONEMATACEAE

Tribonema bombycinum f. *tenue* Haz.

Franklin County, (11682), In a fresh water stream, shore of Alligator Bay, east of St. Teresa.

BOTRYDIACEAE

Botrydium granulatum (L.) Grev.

Wakulla County, (11438), Wet ground in a ditch near St. Marks River, Port Leon.

OCHROMONADACEAE

Dinobryon cylindricum Imh.

Bay County, (10905), Wet sand on the shore of fresh water pond in the sand dunes beside U. S. 98 about one-half mile east of the junction with state highway 70. Lullwater Beach.

DINOPHYCEAE

Hemidinium nasutum Stein

Franklin County, (1025), Wilson's Beach, Alligator Harbor.
Escambia County, (10842), On a tide-pool on the Beach of the Gulf of Mexico, west of the village of Gulf Beach.

ECTOCARPACEAE

Ectocarpus Lyngbye sp.

Bay County, (10941b), Washed ashore in St. Andrews Bay at Frankfort Street and Beach Drive, St. Andrews, Panama City.
Wakulla County, (11777a), On Sargassum washed ashore on the east bank of East River, west of St. Marks Lighthouse on the Gulf of Mexico at the mouth of St. Marks River.

DICTYOTACEAE

Dictyopteris delicatula Lamx.

Pinellas County, (1515), Tides Beach, St. Petersburg.
Franklin County, (1520), Wilson's Beach near Lanark.

BANGIACEAE

Erythrocladia subintegra (Kold.) Rosenb.

Pinellas County, (1513), Tides Beach, St. Petersburg.

Goniotrichum alsidii (Zanard.) Howe

Franklin County, (11708a), Washed in along the shore of St. George Sound, Carrabelle Beach.

CHANTRANSIACEAE

Rhodochorton Rothii (Turt.) Nag.

Franklin County, (11702a), On *Agardhiella tenera* (J. Ag.) Schmitz., washed up on the shore of St. George Sound, half-way between Eastpoint and Carrabelle.

BATRACHOSPERMACEAE

Batrachospermum procarpum Skudja.

Leon County, (11248), In running water of the drain between Ochlockonee River and Lake Iamonia.

Batrachospermum macrosporum Mont.

Leon County, (11248), In running water of the drain between Ochlockonee River and Lake Iamonia.

ERYTHROTRICHIACEAE

Compsopogon sp.

Franklin County, (10954a), Washed ashore from Apalachicola Bay at the east end of the John Gorrie Causeway, west of Eastpoint.

RHODOPHYLLIDACEAE

Agardhiella tenera (J. Ag.) Schmitz.

Franklin County, (2514), Washed ashore on Perkins Beach, Alligator Harbor.

Levy County, (11202), Washed ashore at the Municipal Airport, Cedar Keys.

Franklin County, (11702), Washed up on shore on St. George Sound half-way between Eastpoint and Carrabelle.

Franklin County, (11707), Washed in along the shore of St. George Sound, Carrabelle Beach.

Catenella opuntia var. pinnata (Harv.) J. Ag.

Franklin County, (11724), Washed up on the south shore of Ochlockonee Bay at the bridge on state highway 30, south of Panacea.

SPHAEROCOCCACEAE

Hypnea musciformis (Wulf.) Lamx.

Franklin County, (1047), Alligator Harbor on Alligator Point.

Franklin County, (11708d), Washed in along the shore of St. George Sound, Carrabelle Beach.

DELESSERIACEAE

Caloglossa Leprieurii (Mont.) J. Ag.

Franklin County, (11724b), Washed up on south shore of Ochlockonee Bay at the bridge on U. S. 30, south of Panacea.

Franklin County, (11673), Intertidal on the shore of St. George Sound at the mouth of New River, Carrabelle.

Franklin County, (11656), Intertidal on stumps on the shore of Apalachicola Bay west of limits of Apalachicola.

Escambia County, (10615), Shore of Pensacola Bay north of the Bay Bridge on U. S. 98, Pensacola.

Levy County, (11137), Intertidal on Mangrove on the shore opposite the municipal wharf, Cedar Keys.
Wakulla County, (11466), Intertidal in St. Marks River, Port Leon.

RHODOMELACEAE

Bostrychia sp.

Gulf County, (11646), Intertidal stream entering St. Joseph Bay by U. S. 319, north of the road Constitution Park, Port St. Joe.
Franklin County, (11675a), Intertidal on the shore of St. George Sound at the mouth of New River, Carrabelle.
Bay County, (11605), Intertidal on the sea wall, St. Andrews Bay, Cove Hotel, Panama City.
Taylor County, (11241), On pilings between tide limits on the shore of the Steinhatchee River in the southern part of Steinhatchee.
Wakulla County, (11724b), Washed up on the south shore of the Ochlockonee Bay at the bridge on state highway 30, south of Panacea.
Walton County, (10724a), Intertidal on rocks in Choctawhatchee Bay at the east end of Santa Rosa Island.
Wakulla County, (11762), Intertidal on the stone jetty west of St. Marks Lighthouse on the Gulf of Mexico at the mouth of the St. Marks River.

Dasya pedicellata Ag.

Wakulla County, (11778), Washed ashore in the mouth of East River, west of St. Marks Lighthouse, on the Gulf of Mexico at the mouth of the St. Marks River.

Digenia simplex (Wulf.) Ag.

Franklin County, (11717), Washed up on the shore of St. George Sound at the mouth of New River, Carrabelle.
Taylor County, (11558), Adams Beach.
Wakulla County, (11787), On rocks of the jetty in shallow water west of St. Marks Lighthouse on the Gulf of Mexico at the mouth of the St. Marks River.

Laurencia Poitei (Lamx.) Howe.

Bay County, (11429), Washed ashore in St. Andrews Bay at the west end of Hathaway Bridge, west of Panama City.[4]

Polysiphonia Greville sp.

Franklin County, (11712), Washed up on the shore of St. George Sound at the mouth of New River, Carrabelle.

CERAMIACEA

Ceramium (Roth.) Lyngbye. sp.

Santa Rosa County, (10629b), Washed ashore in Santa Rosa Sound east of Pensacola Beach.

Centroceras clavulatum (Ag.) Mont.

Franklin County, (1523), Wilson's Beach near Lanark.

Spyridia filamentosa (Wulf.) Harv.

Franklin County, (11708c), Washed in along the shore of St. George Sound, Carrabelle Beach.

CORALLINACEAE

Jania Lamx. sp.

Escambia County, (10566), Washed up from the Gulf of Mexico into the dunes west of Gulf Beach.

Melobesia Lamx. sp.

Taylor County, (1591), Deakle Beach, south of Adams Beach.

Grateful acknowledgment is made to Dr. Drouet for the determinations of all species listed (with the one exception noted), for his helpful suggestions, criticisms, and aid in collecting.

[4] Determined by H. J. Humm.

THE ALGAE OF A MODIFIED BRACKISH POOL[1]

Dorothy E. Crowson

Algae, especially those of the plankton, comprise a significant portion of the total organic matter in both fresh and salt water. All factors being considered, fish production will be greater in a body of water which is favorable for growth of algae. With the growing interest on the part of farmers and others in small lakes and ponds as a means for the production of human food, ecological studies of such waters are of increasing importance. These may contribute toward the goal of a more intelligent management of such factors as affect the growth or culture of algae.

The study of Port Leon Pool (Lake Philips) was begun in July 1948. This pond is located in the St. Marks National Wildlife Refuge, Wakulla County, Florida. The study includes all groups of fresh water algae found there, including representatives of the Myxophyceae, Chlorophyceae, Rhodophyceae, and Heterokontae which were collected in the pool, the runoff, and on the banks of the pond over a period of eleven months, from July 1948, to June 1949.

During this study period a total of 49 species were recorded: 20 Myxophyceae, 27 Chlorophyceae, 1 Rhodophyceae, and 1 Heterokontae.

It was the principal purpose of this study not only to acquire a check list of the algal population of this area, but also to present observations concerning the ecological factors which might explain seasonal and geographic distribution of the various species represented.

The check list is by no means complete nor has it been possible within the period of time available to record the full range of ecological factors. Much additional collecting and investigations over a long period will be necessary for a thorough analysis of such a habitat.

The writer is indebted to Dr. Francis Drouet, Chicago Natural History Museum for all identifications except the one noted, and to Dr. C. S. Nielsen, Florida State University, for assistance during the study.

FIELD OBSERVATIONS

In connection with the collections of algae, various ecological data were observed and recorded. The vascular plants of the area were

[1] Contribution No. 37, Botanical Laboratory, Florida State University.

studied in relationship to specific zonation and the results recorded. Water depth measurements were taken of each zone in order to calculate the maximum and minimum depths at which plants grow, and these data are included.

In the field, determinations of temperature, salinity, and hydrogen-ion concentration were made at the time collections of the algae were made. (Table 1). The silver-nitrate titration method was used for salinity tests. Hydrogen-ion concentration was determined by two methods: colorometric using red indicators, phenol red and brom thymol blue, and electrometric by means of a Beckman apparatus. Temperature of the pool, taken at various levels in the water, were correlated with surrounding air temperatures.

PHYSICAL FACTORS

Temperatures—Because of the shallowness and large expanse of surface, the water of the pool has a marked tendency to fluctuate with the temperatures of the atmosphere. However, since the specific heat of water is so great, a pond or any body of water must absorb vast quantities of heat in order to increase its temperature by 1° C. As was expected in Port Leon Pool, there was a delay in the warming of the water in spring, and a delay in cooling in autumn due to the large amounts of heat.

Salinity—Water quality tests for the early years of impoundment are not available, but records of the Fish and Wildlife Service show that in the early history of the pool it was a typical brackish waterfowl pond, and supported an abundance of good waterfowl food-plants. In 1937 a check-list of the vascular plants included such species as *Potomogeton perfoliatus, P. pectinatus,* and *Castalia flava.* Besides, it is stated that the genera *Naias, Utricularia,* and *Scirpus* were there as well as the family Characeae. All of these plants show wide range of salinity tolerance. In a recent report, E. B. Chamberlain, Jr. (1), Wildlife Biologist of the Florida Game and Fresh Water Fish Commission, deals with salinity ranges of some sixty-three waterfowl food-plants. His analysis, expressed as per cent of sea water considering 35,000 ppm total chlorides as full strength, shows that *Potomogeton pectinatus* has a salinity range of 0.3 to 23.5, *Castalia flava,* 0.0 to 10.8, and *Chara* spp., 0.0 to 55.3.

Over the last ten-year period, data show that brackishness declined gradually as the chlorides were leached out and carried in solution

over the spillway. When W. P. Baldwin, Refuge Management Biologist, U. S. Fish and Wildlife Service, first tested the pool in 1947, the decade of flushing had already converted the pool to a fresh-water pond. Tests since this date show that this has been the case except in two tests in 1948 made after a prolonged dry season and no overflow from the pond. These tests, one made by Baldwin and another by the writer, indicate a "trace" of chlorides (three parts per thousand or 0.1 per cent of sea strength) present in the water. As might be concluded, this would indicate that the bottom soils of the pond still retained a little of the original chlorides. However, tests made after the drought had ended indicated that the water was entirely "fresh".

CHEMICAL FACTORS

Hydrogen-ion concentration—The hydrogen-ion factor is such a pertinent factor in the metabolism of living organisms that its importance in growth and distribution of the algae cannot be over-emphasized. The extent of correlation between the hydrogen-ion concentration and individual species has not been considered in this study, but in many cases it has been demonstrated to be the limiting factor.

Hydrogen-ion tests on the Port Leon Pool show that the pond is typically acid as are all stained pools which receive acid flat-woods drainage. In the fall of 1947 Baldwin[2] obtained an average pH reading of 5.7. Tests taken after this showed pH variations from 5.9 to 6.8. Table I shows pH and salinity ranges taken by Baldwin and the writer.

GENERAL DESCRIPTION OF POND

This pool was the first one of a series to be constructed at St. Marks around 1936. Early ecological data are scarce, but it is known that the area impounded was originally a *Juncus roemerianus* salt marsh on firm sand, and was influenced by tides. The construction of the dike cut off this periodical tidal influx and stored up the fresh water from upland drainage. This resulted in the formation of a body of water some thirty acres in extent between the dike and bridge, with a long shallow arm continuing inland from the bridge. The drainage basin supplying the pool, according to Baldwin, covers approximately 1000 acres.

[2] Letter from W. P. Baldwin, Refuge Management Biologist, U. S. Department of Interior, Fish and Wildlife Service, December 23, 1949.

The bottom of the pond is of mucky character and supports a variety of rooted plants. Welch (4) considers the word bottom to include all parts of the bottom of a lake basin from the water's edge to the deepest region. Ponds are of two general classes: (1) those with bare bottoms and (2) those with bottoms composed of soft, accumulated deposits. This pond would fit into the latter classification.

ZONATION

The fact that the pond becomes progressively and concentrically deeper from the shore towards the center accounts for different aquatic plant associations, which are arranged in zones parallel to the shore line. Not only were the vascular plants found to be restricted, but also to some extent certain species of algae. On the slopes, just above the water mark there is a growth of wax myrtle (*Myrica cerifera*) and a willow (*Salix longipes*). The algae associated with these and found growing on the wet soil were *Scytonema figuratum, S. tolypotrichoides, Microcoleus acutissimus, M. rupicola, Stichococcus subtilis, Porphyrosiphon Notarisii,* and *Stigonema panniforme.* These *Myrica* and *Salix* land-types grade off into a zone of emergent flowering plants with roots in accumulated soft mud. The dominating vascular plants in this zone are common cat-tail (*Typha latifolia*), the arrowgrass (*Sagittaria lancifolia*), and pickeral weed (*Pontederia lanceolata*). Other associated forms are the sedge (*Scirpus americanus*) and the smartweed (*Polygonum puntatum?*). The majority of the plants of *Sagittaria lancifolia* occurred in depths ranging from 1 to 18 inches. A few isolated patches were present at depths of 24 and 25 inches, but in most cases plants were restricted to depths less than 18 inches. Most of the plants of *Typha latifolia* were found growing in less than 15 inches of water. Depths of water up to 18 inches supported most of the *Pontederia lanceolata,* but a few individuals occurred in water of 24 inches. In this zone these vascular plants offer a place of attachment for many of the epiphytic algae, and it was in this zone that the majority of species occurred. Those most frequently found were *Hapalosiphon pumilus, Oscillatoria splendida, O. tenus, Coleochaete scutata, Symploca Muscorum, Tetraspora gelatinosa, Microspora amoena, Chaetophora pisiformis, Stigeoclonium lubricum, Oedogonium* sp., *Spondylosium* sp., and *Micrasterias* sp.

Below this zone of *Sagittaria-Typha-Pontederia* comes a second belt of rooted plants with floating leaves where mean depth permits. This

is the *Brasenia* zone. Of greatest abundance here is the watershield *(Brasenia Schreberi)* in depths of 10 to 40 inches of water. The majority of plants occur in the outer margin of this, but a few plants were observed in depths as great as 60 inches. Here and there the white waterlily *(Castalia odorata)* appears with plants of *Brasenia,* but only in the deeper water areas of this zone. In the spring, the yellow insectiverous bladder-wort *(Utricularia inflata),* with its capillary dissected leaves and bearing small bladders which float the plant, occupies a conspicuous area next to *Brasenia.* The algal forms associated with *Brasenia* and *Utricularia* were *Tetraspora gelatinosa, Chastophora pisiformis, Ocdogonium* sp., *Zoochlorella parasitica, Mougeotia* sp., *Desmidium Grevilli, Cosmarium* sp., *Micrasterias* sp., and *Tribonema bombycinum.*

On the inner edge of this zone, and nearer the deeper water, *Castalia odorata* appears. This species shows an extremely wide acidity tolerance, and is found in most acid ponds in this vicinity. The algal flora in this association is limited to members such as *Desmidium Swartzii, Zoochlorella parasitica, Spondylosium pulchrum, Eurastrum* sp., and *Micrasterias* sp.

The open water, that is, the area in which there are no attached aquatics, represents a very small portion of the pond and maintains such growth as desmids, diatoms, and other flora. These open areas measured only 67 inches in the deepest places. Species of *Desmidium, Cosmarium, Triploceras, Micrasterias,* and *Eurastrum* were found here.

SEASONAL DISTRIBUTION

The algal flora of the pond varies from season to season. Throughout the year certain species seemed to appear suddenly in great abundance and then disappear in a few months. The Chlorophyceae were the dominant group throughout the seasons. During the period of study two maximal and two minimal periods of production were noted. The greatest development of the greens occurred in the late summer or early fall and lowest production in the winter and midsummer. At the times of maxima, large mats of the filamentous greens were formed in various shallow areas. Upon identification, those responsible for these mats were found to be species of *Oedogonium, Bulbochaete, Spirogyra,* and *Mougeotia.* In winter and midsummer the mats disappeared, and the same species occurred, but less luxuriantly. Other Chlorophyceae observed taking this form were

Chaetophora pisiformis, prolific on *Sagittaria* leaves and stems; *Stigeoclonium lubricum, S. tenue,* in shallow water; and *Coleochaete scutata, C. soluta,* epiphytic on *Scirpus* and *Sagittaria.*

The periodic shifts in maximal and minimal growth may vary greatly in any pond, depending upon such factors as temperature, light, and dissolved oxygen. There is a complexity of changes which comes with the seasons and influences directly or indirectly each species. As these responses are made to the changes imposed, the distribution is consequently influenced.

The Myxophyceae follow much the same maximal and minimal periods as do the Chlorophyceae. It is well established that the blue-greens are summer and autumn forms. This seems to be the case in many of the temperate ponds and lakes. However, in Port Leon Pool the blue-greens occurred regularly with some increase in abundance in spring, a decrease in the hot summer months, and an increase again in the fall. In comparing seasonal distribution of the Chlorophyceae and the Myxophyceae, the latter did not exhibit as much of a fluctuation as did the Chlorophyceae, even in the most abundant species.

The blue-green found growing in greatest abundance the entire year was *Hapalosiphon pumilus.* It is truly an aquatic species, and epiphytic on all the vascular plants.

Only one member of the Rhodophyceae was found, but it showed a noted seasonal distribution. This was identified by Dr. Fr. Skuja as *Batrachospermum guyanense* which was present in the sexual stage only during the month of March when the water was cool. It was found on rocks in the shade of the spillway and in running water. Lewis Flint[3] at Louisiana State University reports finding this species in Louisiana, and Albert Robinson, Jr. in Arkansas, but no reference can be located by the writer as to its having been found in Florida.

SUMMARY

A study of the algae with pertinent ecological factors was made on a modified brackish pool in the St. Marks Wildlife Refuge, Wakulla County, Florida.

Periodic trips to the pond were made over a period of eleven months in order to make collections and to acquire various chemical and

[3] Letter from L. H. Flint, Louisiana State University, Baton Rouge, Louisiana, February 2, 1950.

physical data. This data showed that the pond was acid and entirely "fresh."

The vascular plants, and to some extent the algae, were observed to be arranged in definite zones paralleling the shore line; this restriction was attributed to varying depths of the pond.

The algae were shown to have a seasonal distribution; maximal and minimal growth periods being noted. The Chlorophyceae were the dominant group, both in quantity and number.

Only one member of the Rhodophyceae, *Batrachospermum guyanense,* was found. It was present in the sexual stage only in the month of March; its occurrence was restricted to the shade of the spillway.

During this study period a total of 49 species were recorded: 20 Myxophyceae, 27 Chlorophyceae, and 1 Heterokontae, and 1 Rhodophyceae. Much additional collecting and investigations over a longer period will be necessary to make a complete list of the species and to determine the full range of ecological factors.

CHECK LIST OF SPECIES FOUND

CHROOCOCCACEAE

Gloeocapsa alpicola (Lyngb.) Born.

STIGONEMATACEAE

Hapalosiphon pumilus B. & F.
Stigonema panniforme B. &. F.

SCYTONEMATACEAE

Aulosira implexa B. & F.*
Scytonema figuratum B. & F.
Scytonema tolypotrichoides B. & F.
Tolypothrix lanata B. & F.

OSCILLATORIACEAE

Lyngbya Diguetii Gom.
Lyngbya versicolor Gom.
Microcoleus acutissimus Gardn.
Microcoleus rupicola (Tild.) Dr.
Oscillatoria princeps Gom.
Oscillatoria splendida Gom.
Oscillatoria tenuis Gom.
Plectonema Nostocorum Gom.

Porphyrosiphon Notarisii Gom.
Schizothrix aikenensis (Wolle) Philson*
Schizothrix purpurascens Gom.
Schizothrix rivularis (Wolle) Dr.*
Symploca Muscorum Gom.

TETRASPORACEAE

Tetraspora gelatinosa (Vauch.) Desv.

ULOTRICHACEAE

Stichococcus subtilis (Kütz) Klerck.

MICROSPORACEAE

Microspora amoena (Kütz) Rabenh.*

CHAETOPHORACEAE

Chaetophora pisiformis (Roth.) Ag.*
Stigeoclonium lubricum (Dillw.) Kütz
Stigeoclonium tenue (Ag.) Kütz

PROTOCOCCACEAE

Protococcus viridis Ag.

COLEOCHAETACEAE

Coleochaete scutata Breb.*
Coleochaete soluta (Breb.) Pringsh.*

OEDOGONIACEAE

Oedogonium sp.
Bulbochaete sp.

OOCYTACEAE

Zoochlorella parasitica Brandt. in sponge

SCENEDESMACEAE

Scenedesmus acuminatus (Lagerh.) Chod.
Tetrallantos Lagerheimii Teiling

ZYGNEMATACEAE

Mougeotia sp.
Spirogyra sp.
Zygnema sp.
Zygogonium ericetorum (Roth.) Kütz

DESMIDIACEAE

Cosmarium sp.
Desmidium Grevillei (Kütz) DeBary
Desmidium Swartzii Ag.
Eurastrum sp.
Micrasterias sp.
Pleurotaenium subcoronulatum (Turn.) W. & G. S. West*
Pleurotaenium sp.
Spondylosium pulchrum (Bail.) Arch.*
Triploceras verticillatum Bail.*

TRIBONEMATACEAE

Tribonema bombycinum (Ag.) Derb. & Sol.

BATRACHOSPERMACEAE

Batrachospermum guyanense (Montagne) Kütz†

* Recorded for the first time in this area.
† Originally reported as *Batrachospermum australe* Coll. (B).

TABLE I

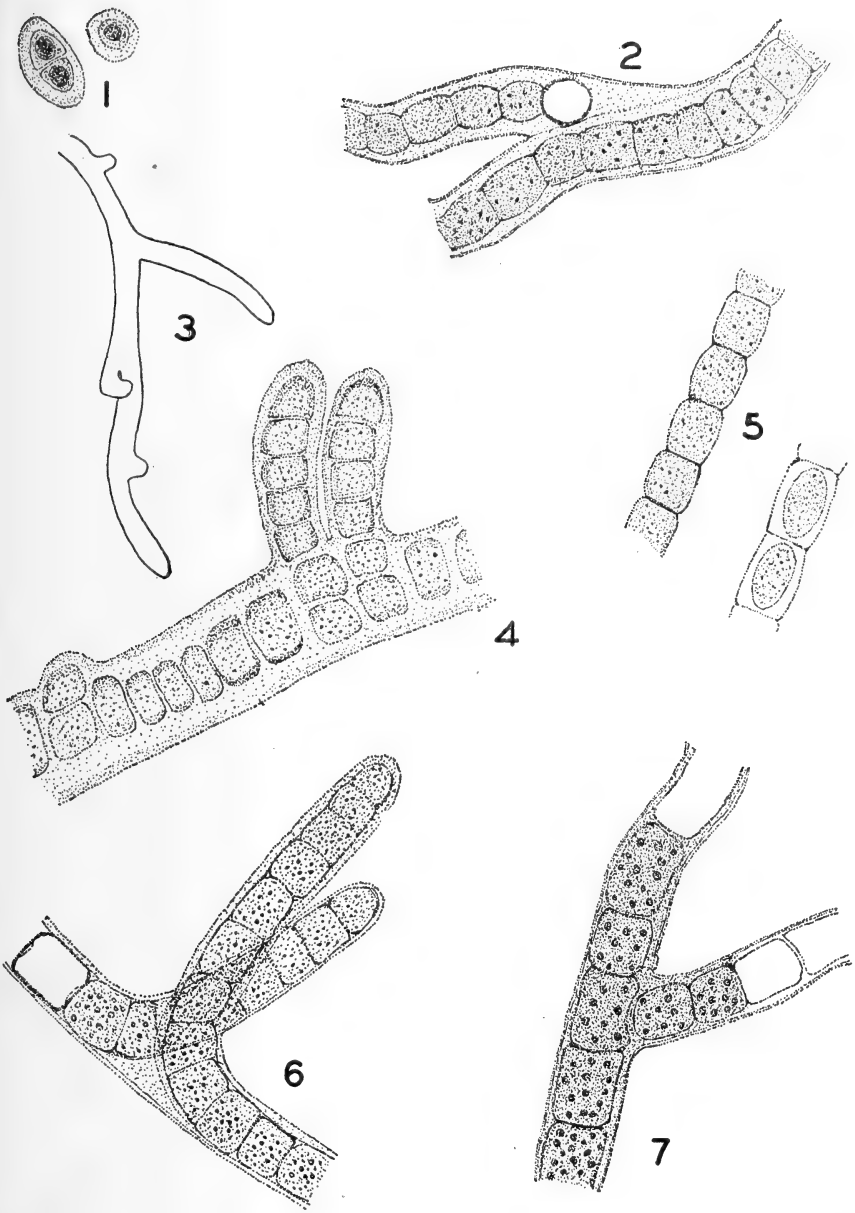
WATER QUALITY DATA—PORT LEON POOL

Date	Number Readings	pH Range	pH Average	Salinity % Sea Strength	Rainfall Inches
August 9, 1947.....	5	5.5–5.9	5.7	0.0	4.44
May 24,1948.....	2	.....	...	0.1	2.30
July, 1948.....	3	6.0–6.3	6.1	0.1	5.24
August 25, 1948....	2	5.9–6.3	6.1	0.0	10.48
February 11, 1949..	1	.....	...	0.0	4.06
March 1949.....	2	5.7–5.9	5.7	0.0	3.62
April 9, 1949.....	3	5.6–6.1	5.9	0.0	5.11
May 15, 1949.....	2	6.0–6.2	6.1	0.0	1.75
November 2, 1949..	1	6.8	6.8	0.0	.....

EXPLANATION OF PLATE I

1. *Gloeocapsa alpicola* (Lyngb.) Born.
2. *Tolypothrix lanata* B. & F.
3. *Stigonema panniforme* B. & F. Habit sketch
4. *Stigonema panniforme* B. & F.
5. *Aulosira implexa* B. & F.
6. *Scytonema tolypotrichoides* B. & F.
7. *Hapalosiphon pumilus* B. & F.

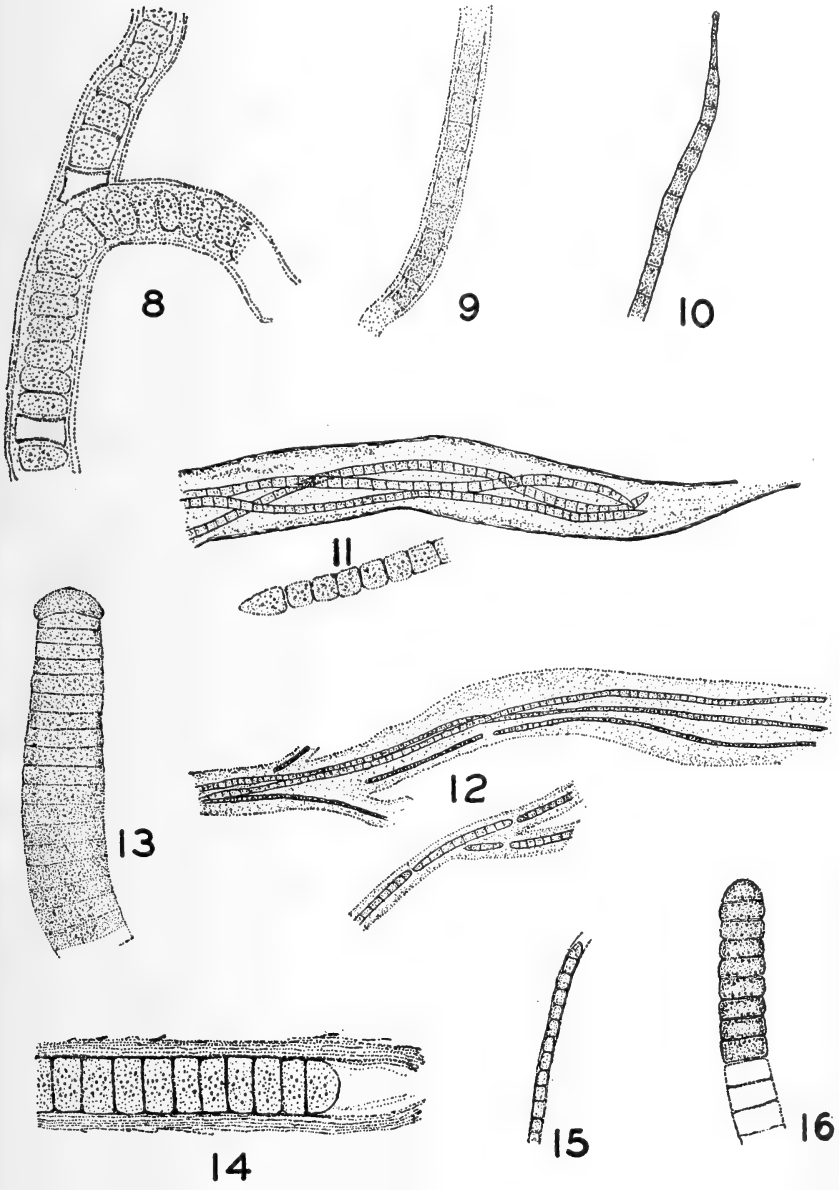
PLATE I



EXPLANATION OF PLATE II

8. *Scytonema figuratum* B. & F.
9. *Lyngbya versicolor* Gom.
10. *Oscillatoria splendida* Gom.
11. *Schizothrix purpurascens* Gom.
12. *Schizothrix aikenensis* (Wolle) Philson
13. *Oscillatoria princeps* Gom.
14. *Porphyrosiphon Notarisii* Gom.
15. *Plectonema Nostocorum* Gom.
16. *Oscillatoria tenuis* Gom.

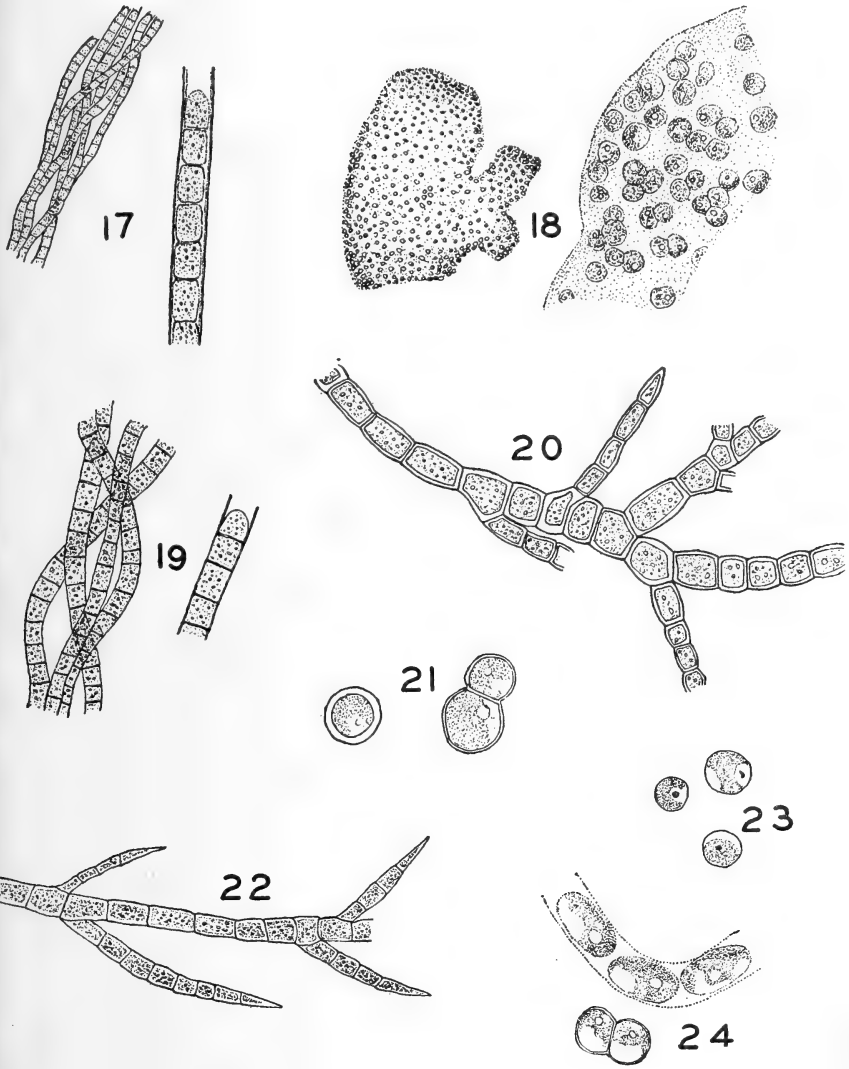
PLATE II



EXPLANATION OF PLATE III

17. *Symploca Muscorum* Gom.
18. *Tetraspora gelatinosa* (Vauch.) Desv.
19. *Schizothrix rivularis* (Wolle) Dr.
20. *Stigeoclonium lubricum* (Dillw.) Kütz
21. *Protococcus viridis* Ag.
22. *Stigeoclonium tenue* (Ag.) Kütz
23. *Zoochlorella parasitica* Brandt. in sponge
24. *Stichococcus subtilis* (Kütz) Klerck.

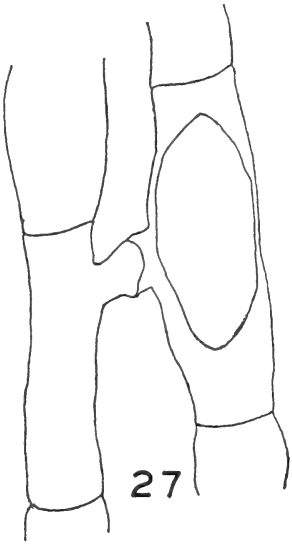
PLATE III

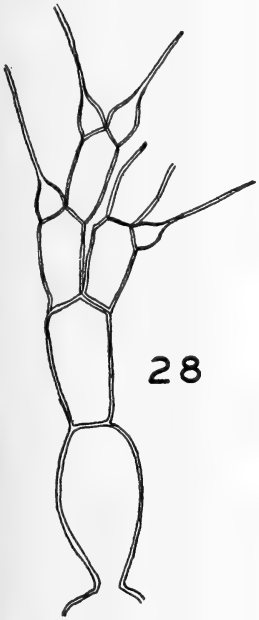


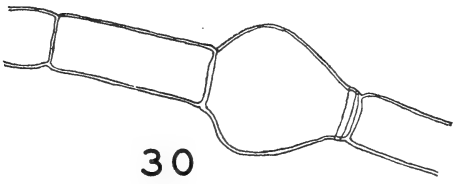
EXPLANATION OF PLATE IV

25. *Microspora amoena* (Kütz) Rabenh.
26. *Spirogyra* sp. Vegetative cell
27. *Spirogyra* sp. Zygote
28. *Bulbochaete* sp.
29. *Oedogonium* sp. Vegetative cell
30. *Oedogonium* sp. Zygote

PLATE IV



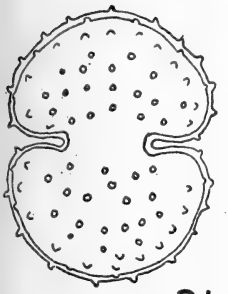




EXPLANATION OF PLATE V

31. *Cosmarium* sp.
32. *Pleurotaenium* sp.
33. *Pleurotaenium* sp.
34. *Triploceras verticillatum* Bail.
35. *Spondylosium pulchrum* (Bail.) Arch.

PLATE V



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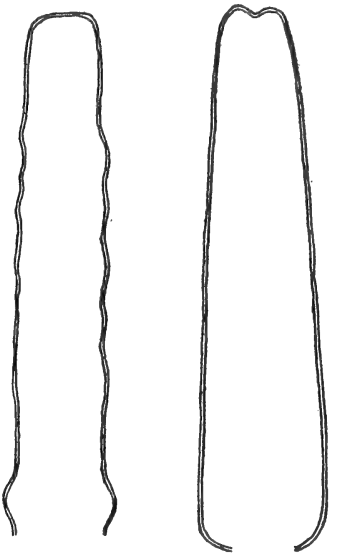
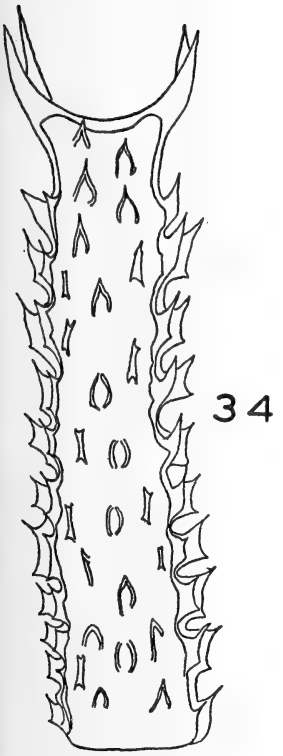


32 33



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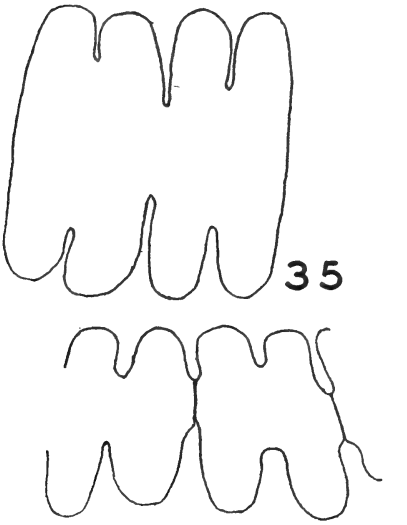
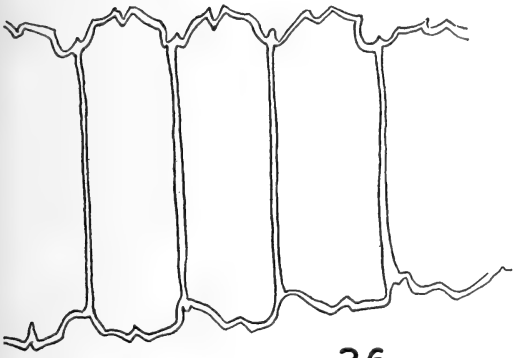


35

EXPLANATION OF PLATE VI

36. *Desmidium Swartzii* Ag.
37. *Desmidium Grevillei* (Kütz) DeBary
38. *Zygnema* sp.
39. *Euastrum* sp.
40. *Euastrum* sp.

PLATE VI



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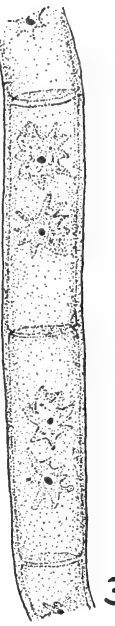

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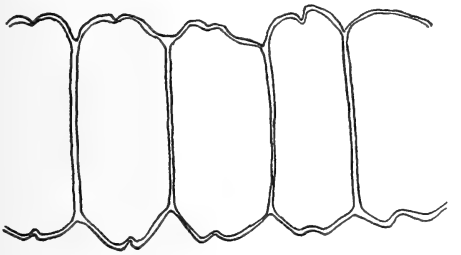

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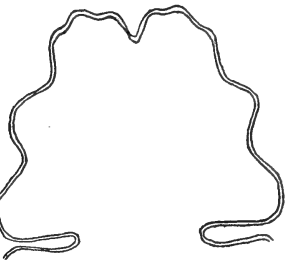


40

EXPLANATION OF PLATE VII

41. *Tribonema bombycinum* (Ag.) Derb. & Sol.

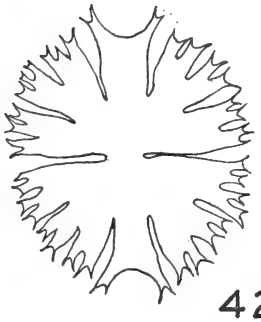
42. *Micrasterias* sp.

43. *Batrachospermum guyanense* (Montagne) Kütz

44. *Batrachospermum guyanense* (Montagne) Kütz

PLATE VII

41



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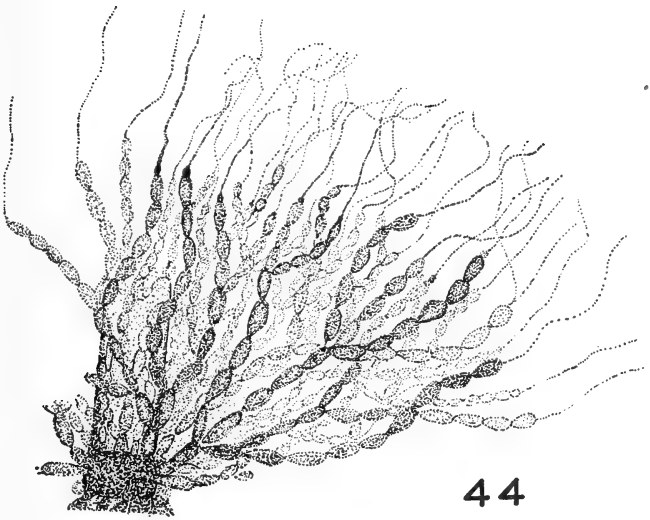


44

EXPLANATION OF PLATE VIII

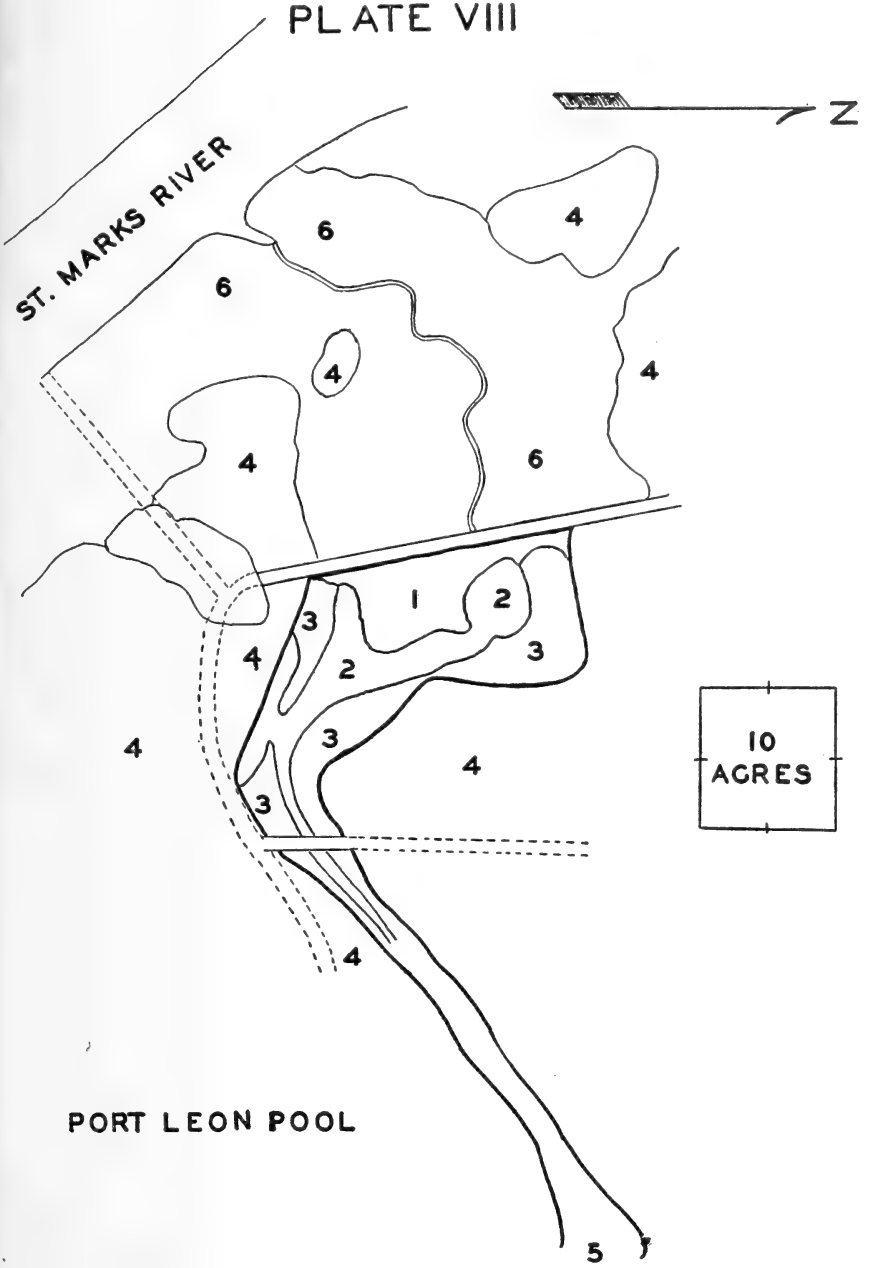
Port Leon Pool (Lake Philips)

Photographic enlargement from aerial photograph, Tal-1-149. 1948. W. P. Baldwin. The pond proper is within the heavy outlined area.

ZONATION

1. *Utricularia inflata* and open water
2. *Brasenia Schreberi*
3. *Sagittaria-Typha-Pontederia*
4. Pine flat-woods
5. *Spartina-Cladium* savannas
6. *Juncus roemerianus* (salt-marsh)

PLATE VIII


ST. MARKS RIVER
N
6
6
4
4
4
4
6
1
2
3
4
2
3
3
4
3
4
4
10
ACRES
PORT LEON POOL
5

EXPLANATION OF PLATE IX

45. Northeast side of pond showing the pine flat-woods (4) in background and zones of *Sagittaria-Typha-Pontederia* (3) and *Brasenis* (2).

46. East side of pond showing definite zones of *Typha* (3) and *Brasenis* (2). *Castalia* in foreground.

PLATE IX

EXPLANATION OF PLATE X

47. Southeast side of pond. Pine flat-woods (4) in background. Next, *Typha* zone (3), and open water area (1).

48. *Juncus roemerianus* (salt-marsh) on west side of pond. The area which is seen in the foreground supports a few plants of *Cladium* and *Typha* because of the overflow from the pond.

PLATE X

Literature Cited

1. CHAMBERLAIN, JR., E. B. 1949. "Florida Waterfowl Survey"—F. A. Project 19-R, *Quarterly Report* for Oct., Nov., Dec., 1949. Fla. Game and Fresh Water Fish Commission. Tallahassee.

2. DROUET, FRANCIS. 1938. *The Oscillatoriaceae of Southern Massachusetts.*

3. NIELSEN, C. S. and G. C. Madsen. 1949. "Preliminary Check List of the Algae of the Tallahassee Area," *Quarterly Journal of the Florida Academy of Sciences.* 11: 111-117.

4. WELCH, PAUL S. 1935. *Limnology.* New York: McGraw-Hill Book Co., Pp. 338.

THE HEPATIC SPOROPHYTE — I.

A note on seta elongation.[1]

KENNETH A. WAGNER

Many observers have called attention to the rapid elongation of setae of liverworts. In fact, this is one of the most reliable characteristics used to distinguish this group of plants from the mosses. But, beyond noting that the elongation is rapid and not accompanied by cell division, very little is known about this process.

This report gives the results of some observations on seta development but does not attempt to explan the cause of the peculiar sequence of cell elongation other than to point out a possible source of the stimulus.

The material used was a collection of *Jungermannia lanceolata* found in the vicinity of Ann Arbor, Michigan. The collection was made early in March while snow was still on the ground. A large colony was found where the snow had melted around a spring.

The sporophyte of *Jungermannia lanceolata,* figure 1, agrees in type of foot with that of *Lepidozia, Lophocolea,* and *Cephalozia.* The sporophyte foot of these three genera is described by Evans.[2] In the number of vertical rows of cells, though, *J. lanceolata* is similar to species of *Lophozia, Gymnomitrium,* and *Frullania.* Figure 3 illustrates an unusual condition in the setae of liverworts. Not only is the number of external rows of cells indefinite, as shown in figure 2, but also there is a difference in the number of rows at different levels, sometimes even in the same seta. Very few examples of this condition were seen, however.

The complete elongation of many of the setae was found to occur in six to nine hours.

The data shown in the accompanying graphs were obtained by measuring each cell in five to ten rows of cells in setae in varying stages of elongation. This information is shown on the graphs with cell length on the vertical scale and individual cells listed on the horizontal. Number one on the horizontal, then, is the bottom cell

[1] Contribution No. 38, Botanical Laboratory, Florida State University.

[2] A. W. Evans, "The Classification of the Hepaticae," *Bot. Rev.,* 5:49-96. 1939.

of the seta; number 53 is the cell next to the capsule. Thus we note in figure 4, for example, that the thirty-first cell from the bottom in a one-half millimeter seta was fifteen microns long while the cell the same distance from the bottom in a thirteen millimeter seta was 490 microns long.

In figure 4, exact cell lengths are shown for the cells in one row from a one-half millimeter seta, and in one row from the longest seta measured, a thirteen millimeter seta. This shows the extent to which some cells enlarge. It also indicates that there may be considerable variation in length between adjacent cells. Because of this, it is believed that the important point is what is happening in general regions of the seta, not what is happening to individual cells. Figure 5, then, is obtained by plotting average cell lengths at five cell intervals for the lengths of setae shown. On all seta lengths given, the following system of deriving means was used. The point at which cell five was placed was the average cell length for cells one through ten. The point at which cell ten was placed was the average for cells six through fifteen. This overlapping tends to smooth out the curve without defeating its basic purpose, that of revealing the sequence of cell elongation.

The seta of a sporophyte of one-half millimeter length or less has nearly the same cross-section diameter as a seta in process of elongation or one in which elongation is complete, if the cells are still turgid. Thus, where a cell four microns long before elongation might reach a length of as much as 526 microns, the width of the cells was found to go from about twelve microns to not more than twenty microns. This is an addition of two thirds to the original width compared with an increase of approximately 131 times the original length. Of course, as shown in figure 4, not all cells in any one row elongate so much.

At the time of elongation, reduction division has been completed and the spores are still held in tetrads.

There is some evidence that the stimulus causing the rapid elongation has its origin in the capsule. In the one-half millimeter seta, the longest cells were the uppermost ones. Although this was the shortest seta found at that time, elongation may have been just starting. In the three-fourths millimeter seta, the peak of elongation is definitely at the top although a slight and nearly uniform growth has occurred throughout. The next three successive seta lengths show the movement of this peak progressively downward.

In suggesting the capsule as the source of the stimulus, the writer realizes that this explanation pre-supposes a very even diffusion of the stimulant down through the seta. Considering the rapidity and extent of elongation, it would seem that even a small gradient in the hormone, if that is the causal agent, from one side of the seta to the other would result in sharp bending or even coiling of the seta as it elongated. This does not occur, however. The setae are all straight or very nearly so.

At the completion of elongation the capsule splits and the spores are shed. Very soon after the spores are gone, the seta collapses, becoming too flaccid to support even the empty capsule valves. This collapse of the seta at the loss of the spores might be taken as evidence again that the secret of the elongation lies in the capsule, possibly in the products of spore maturation.

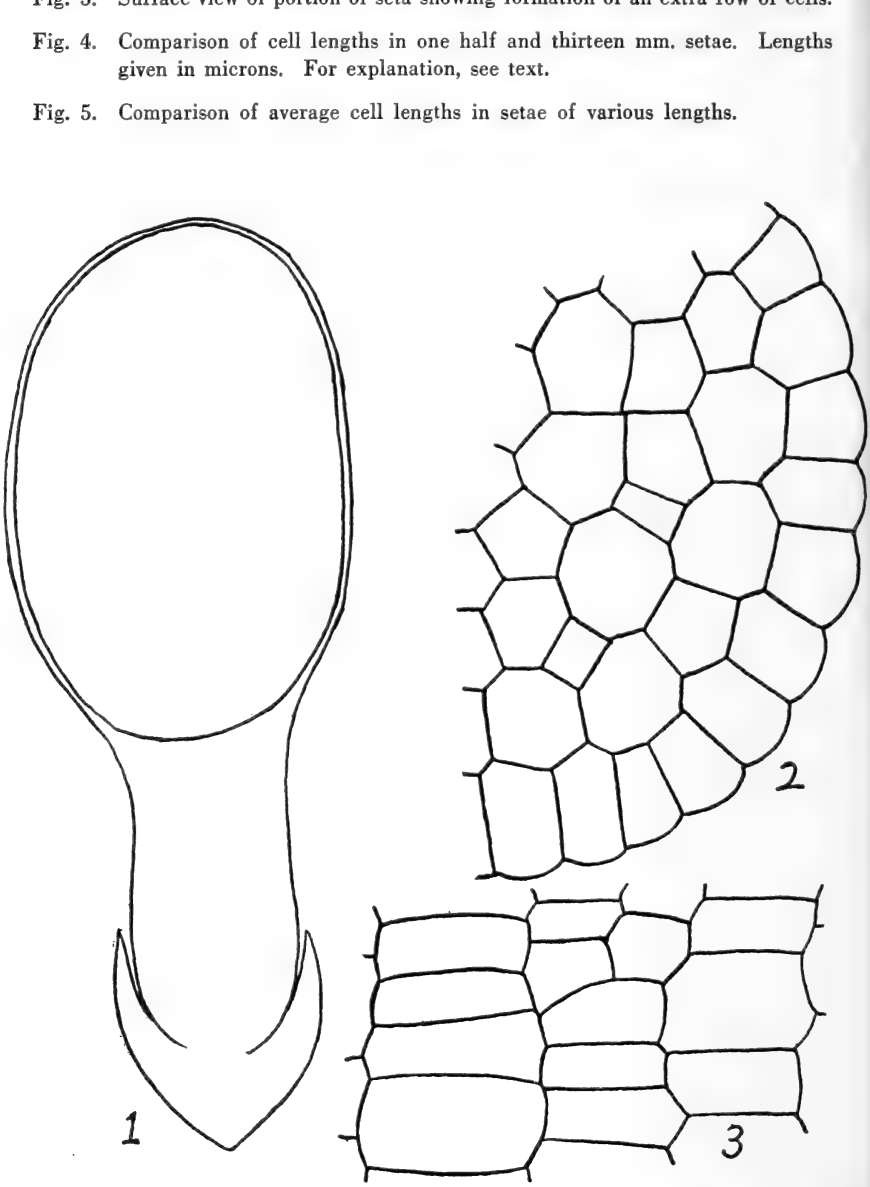
Fig. 1. Sporophyte of *Jungermannia lanceolata* before elongation.

Fig. 2. Portion of cross-section of seta.

Fig. 3. Surface view of portion of seta showing formation of an extra row of cells.

Fig. 4. Comparison of cell lengths in one half and thirteen mm. setae. Lengths given in microns. For explanation, see text.

Fig. 5. Comparison of average cell lengths in setae of various lengths.



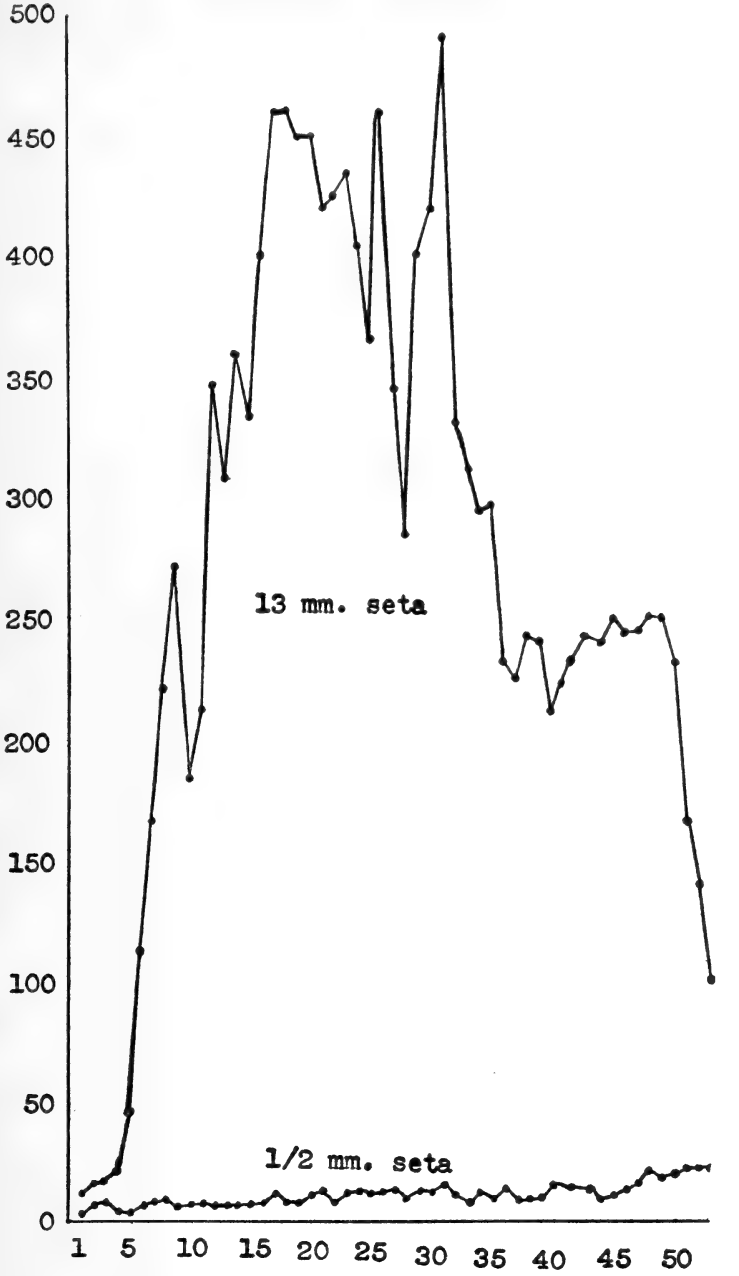

500
450
400
350
300
250
200
150
100
50
0
13 mm. seta
1/2 mm. seta
1 5 10 15 20 25 30 35 40 45 50

FIG. 4

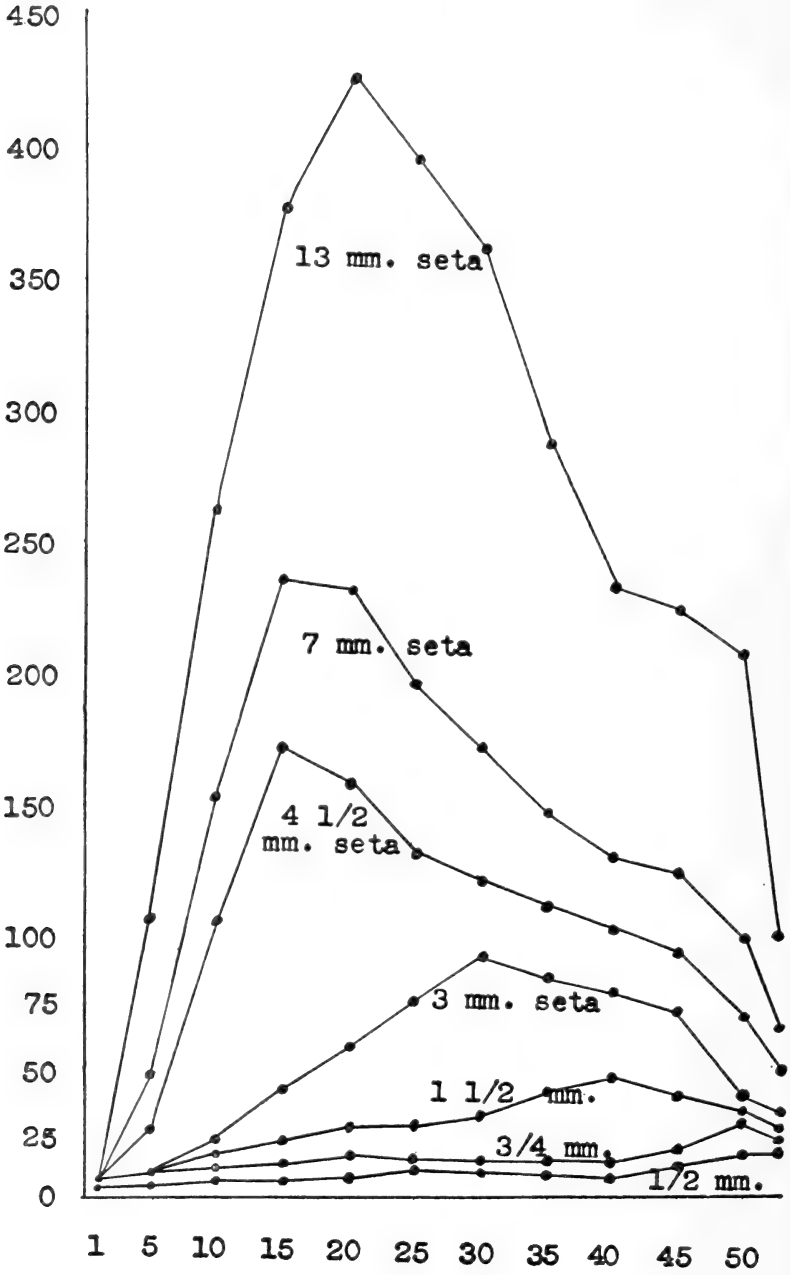

450
400
350
300
250
200
150
100
75
50
25
0
13 mm. seta
7 mm. seta
4 1/2 mm. seta
3 mm. seta
1 1/2 mm.
3/4 mm.
1/2 mm.
1 5 10 15 20 25 30 35 40 45 50

FIG. 5

NOTES ON FLORIDA BRYOPHYTES—I.

Some hepatics new to the state.[1]

KENNETH A. WAGNER AND HERMAN KURZ

Collections of liverworts in the past few years have resulted in the finding of five species not previously reported for Florida. Most of these collections were made by the junior author along Mountain Laurel Creek in Gadsden County. This creek is located about four miles south of River Junction and is a small tributary of Flat Creek, which flows into the Apalachicola River.

All specimens excepts *Notothylas orbicularis* were collected in areas where Tampa limestone crops out. This formation was deposited in early Miocene time over the eroded surface of an Oligocene deposit of Suwannee limestone. In the Gadsden County area, according to Cooke[2], Tampa limestone appears to merge gradually into the overlying Hawthorn formation.

The authors wish to express their appreciation to Dr. T. C. Frye, Dr. Lois Clark, and Dr. Margaret Fulford for confirmation of some identifications and for suggestions on distribution.

Bazzania tricrenata (Wahl.) Trev. Gadsden County, along tributary to Flat Creek south of River Junction, H. Kurz 310. This species was previously known from the Pacific coast, eastern Canada, and northeastern United States south in the mountains to North Carolina. It occurs also in Mexico, Asia, and Europe. Its discovery here in Florida considerably extends its known range in southeastern United States.

Marchantia palacea Bertoloni. Gadsden County, Aspalaga Landing, in deep ravine, R. Schornhurst Breen 2238; Feb. 19, 1950, K. A. Wagner 2301. It occurs in North America primarily in southwestern United States and in Mexico, and is also reported from Asia, Europe and Africa.

Notothylas orbicularis (Schweinitz) Sull. Calhoun County, east bank of the Chipola River along Florida route 20, on crayfish mound in Gum-Cypress swamp, Sept. 1949, K. A. Wagner 2275. It is widely distributed in northern and eastern United States, Europe, and Mexico.

[1] Contribution Number 39, Botanical Laboratory, Florida State University.

[2] C. W. Cooke, *Geology of Florida*, Geological Bulletin 29, Tallahassee, 1945.

The collections nearest the Chipola River station are from Louisiana and North Carolina. This species is restricted to damp soil and exposed roots. It was collected in an area where Duplin marl is a prominent feature. This formation was deposited near the end of the Miocene when the sea again invaded areas south of New Jersey. Duplin marl is found in several quite local areas in the state. This is the first time the genus *Notothylas* has been reported in Florida.

Plectocolea hyalina (Lyell) Mitten. Gadsden County, tributary of Flat Creek south of River Junction, H. Kurz 302, 306, 307, 314. This is a rather widely distributed species. The report for it closest to the Florida station was based on a collection by F. E. Lloyd and F. S. Earle at Auburn, Alabama, which is about 140 miles north of River Junction. *Plectocolea hyalina* occurs on moist, shaded sandstone or more rarely on limestone. It is quite variable in form.

Trichocolea tomentella (Ehrh.) Dum. Gadsden County, tributary of Flat Creek south of River Junction, H. Kurz 301. This species was previously known from northeastern United States west to Wisconsin and south to North Carolina and Georgia. It occurs also in Europe, Asia, and some Pacific islands. Although it has a rather wide range, it is usually quite local. It may be found on sandstone or limestone, on clay banks, or sometimes on soil in wooded bogs and swamps. However, it occurs most often in the cold water running down through a shaded sandstone ravine. This is the first report of this genus in Florida.

MICROSPOROGENESIS IN *SARRACENIA MINOR* WALT.[1]

MARY J. LIVINGSTON

Members of the genus *Sarracenia,* commonly known as the pitcher plants, have long attracted attention because of their peculiar leaf form and their carnivorous mode of securing food. Pitcher plants were first described as early as 1570 by Label and again in 1601 by Clusius. These strange plants were known and collected by the early settlers in North America even before they were named by Tournefort as the genus *Sarracenia,* which name was accepted and used by Linnaeus.

A survey of the literature dealing with the Sarracenias reveals that much has been written from a taxonomic, geographic, and physiological viewpoint. However, few publications are concerned, even remotely, with the sporogeneses of the various species. In 1906 the results of a study of the gametogenesis, fertilization, floral development, and anatomy of *Sarracenia purpurea* L.[2] were published by Shreve. He does not describe completely the behavior of the chromosomes during meiosis I of microsporogenesis. Shreve reports the reduced chromosome number of *S. purpurea* to be twelve, a number now proved by several more recent counts to be incorrect.

Nichols, in 1908, followed Shreve's work on *S. purpurea* with a description of the development of the pollen of *S. flava* L., *S. purpurea, S. variolaris* Michx. *(*now called *S. Minor), S. rubra* Walt., *S. psittacina* Michx., and the hybrids *S. flava* x *variolaris* and *S. flava* x *purpurea.* Here again the investigator does not give an account of each stage of meiosis and does not indicate that her description is true of every species included in her report, although she states that a close similarity prevails in the pollen development of the species investigated. Nichols, too, records the total number of chromosomes in *S. variolaris* and *S. rubra* as "apparently twelve."

In 1919 Russell compared the various structures of hybrid *Sarracenias* and their parents. These comparisons involved both macroscopic and microscopic characters, and led the investigator to the conclusion

[1] Contribution No. 40, Botanical Laboratory, Florida State University.

[2] Authority is cited the first time a species name is used, and not thereafter.

that hybrids are intermediate in form. Russell makes no reference to any cytological details of cell division, either meiotic or mitotic.

In 1948 Tjio, working with two hybrids of the genus, reported the diploid number of chromosomes to be twenty-six. Early in 1949 Hecht published determinations of the somatic chromosome number of several species of *Sarracenia.* He reported twenty-six somatic chromosomes for *S. purpurea, S. psittacina, S. drummondii* Croom, *S. flava, S. jonesii* Wherry, *S. rubra,* and a putative hybrid of *S. drummondii* and *S. flava.* This work involved somatic chromosome counts alone, since only root tip sections were made.

Bell, in 1949, published the findings of his extensive cytotaxonomic study of the *Sarracenias* of North America. In this work he found the reduced chromosome number of all recognized species of *Sarracenia* to be thirteen, thus confirming Hecht's and Tjio's counts of somatic chromosomes for the species investigated by them and adding chromosome counts for the remaining species. The species for which Bell made counts were *S. oreophila* (Kearney) Wherry, *S. sledgei* Macfarlane, *S. rubra, S. psittacina, S. flava, S. drummondii, S. minor,* and *S. purpurea.* Bell states that, within the genus, chromosome morphology is "of no value in interspecific differentiation."

It appears that, in addition to the valuable contribution of the above mentioned works concerned with the cytology of the *Sarracenias,* there is need of further, and perhaps more detailed, cytological investigation concerning the speciation of this group of plants. The present work, started in September of 1948, was intended primarily to provide a chromosome count for various species of the genus, which at that time had not been reported, and to give a detailed description of microsporogenesis of *Sarracenia minor.* The chromosome number of all members of the genus having been published since this work was begun, the count here reported serves to confirm the chromosome determination by Bell for the species *minor.*

Description of Genus

All species of *Sarracenia* are characterized by the possession of hollow, tubular, pitcher-like leaves in which insects are trapped and digested as food material for the plant. The erect or decumbent leaves are further distinguished by a ventral ridge or wing and a terminal hood over the opening of the leaf. The plants are herbaceous with horizontal root stocks. Perfect flowers, subtended by three bracts and

consisting of five persistent sepals, five deciduous petals, numerous stamens and five united carpels, are borne on erect, hollow scapes. The style forms a five-angled, five-rayed umbrella-like expansion covering the stigmas, which are hooked under its angles.

Description of the Species

Sarracenia minor has erect, vertical leaves, the openings of which are overhung by wide, domed lids. The pitcher is slightly curved and tapers toward its base. The wing is widest near the middle of the leaf and becomes narrow at the top and bottom. The hood and upper portion of the leaf opposite the opening are mottled with white areas which are devoid of chlorophyll and variegated with green and purple veins. The edge of the wall of the lower rim of the opening is outwardly reflexed to form the nectar roll. The outer surface of the leaf is sparsely hairy with short, curved hairs.

The scape of *S. minor* is erect and usually shorter than the leaves. The flower is from four to six centimeters broad with petals of clear yellow. The petals are narrowly fiddle-shaped and rounded at the apex. The sepals are ovate and obtuse. The style disk is two to three centimeters in diameter and has notched lobes.

Materials and Methods

Buds of *Sarracenia minor* were collected in March of 1949 from an acid flatwoods along the roadside of U. S. Highway 19, between the Ochlockonee River and the town of Ochlockonee. All fixation was done in the field using equal parts of solutions A and B of Sach's modification of Navashin's solution. Immediately after the buds had been removed from the plants, they were cut longitudinally into two halves, to insure penetration, and placed in a vial of killing and fixing solution. The buds were dehydrated by the tertiary butyl alcohol method and embedded in paraffin. Longitudinal sections were cut at ten microns and stained with Haidenhain's iron alum haematoxylin. Drawings were made with the aid of a camera lucida.

Premeiotic Appearance

The anthers consist of four pollen sacs. In the youngest buds collected, the parietal cells and sporogenous tissue are well differentiated, but tapetal cells are not as yet distinguishable from sporogenous cells. The parietal layer is from two to four cells wide, and the cells com-

posing it are elongate with smaller nuclei than the cells of the sporogenous tissue. The cells making up the sporogenous tissue and tapetum are differentiated by staining intensity, larger size, larger nuclei and isodiametric shape. The sporogenous tissue with the tapetum, in longitudinal section, forms a somewhat cylindrical mass from six to twelve cells wide and from thirty-five to forty cells long.

Actively dividing cells of the sporogenous tissue are frequent, and all stages of mitosis may be observed. The somatic chromosomes as seen on the metaphase plate in a polar view look much alike both in shape and size. The nucleoli of the sporogenous cells are conspicuous. In the pollen sacs in which the final mitotic divisions are occurring, there is a beginning of separation of sporogenous tissue from the parietal layers.

The microsporocytes resulting from the final mitoses of the archesporial tissue are polyhedral and compact. The absence of cells in any stage other than that of the resting microspore mother cells in the locules makes it seem probable that this resting stage between final mitosis and the prophase of meiosis I is a comparatively long one. The large proportion of anther sacs in a single bud which may be found at this resting stage is further indication of its relatively long duration. The microsporocytes plus the cells which are destined to become tapetal cells are, in most cases, completely separated from the parietal cells at this time, but they are as yet indistinguishable from each other.

The nucleus of the resting microspore mother cell is rounded and has a prominent nuclear membrane. Each nucleus contains one, two or more nucleoli and occupies a large portion of the cell. The spherical nucleolus lies in a clear space usually toward the periphery of the nucleus but not adjoining the nuclear membrane. Occasionally a strand of the nuclear reticulum may be seen extending into the clear space surrounding the nucleolus. The cytoplasm appears reticular and compact with no conspicuous vacuoles (fig. 1).

Meiosis I

At the beginning of the prophase of meiosis I, the microsporocytes enlarge; the nucleus shows greater increase in volume in proportion to the rest of the cell. The nuclear reticulum resolves itself into long, slender, dark-staining strands. These leptotene strands of chromatin appear as a more or less continuous thread and are evenly distributed

throughout the cell with the exception of the space occupied by the nucleolus and a clear space surrounding the latter.

At this stage a striking change in the general appearance of the locule is evident. The cytoplasm of the microspore mother cells has pulled away from the cell wall, which has become rather obscure. The microsporocytes now appear less angular and seem to be separating from each other, although their cell walls remain adjoined. The tapetal cells are now clearly distinguishable from the microspore mother cells. The tapetum consists of a ring of cells from one to three cells wide. The cells composing it are not as large as the microsporocytes, and they do not have the rounded appearance of the latter. Instead, the tapetal cells remain angular and of varied shapes. Several phases of mitotic activity may be observed occurring in the tapetal cells at this stage. A number of the tapetal cells are binucleate.

As prophase I progresses, the chromatin threads contract and thicken. The threads now begin to invade the clear space surrounding the nucleolus, soon obliterating it, and appear to join the nucleolus which has shifted to a position near the nuclear membrane. At this point the chromatin strands resemble a loosely tangled mass of yarn which occupies the entire nucleus (fig. 2). As yet no individual chromosomes are discernible. The threads continue to thicken and condense into a tight knot about the nucleolus at one side of the nucleus. This stage, synizesis, progresses with further concentration of the threads about the nucleolus until they, together with the nucleolus, appear as an almost solid, dark-staining mass occurring at one side of the nucleus (fig. 3).

Reversing the process of its formation, the synizetic knot begins to spin out to form an open mass of threads, some of which are now considerably thicker than others. This stage of non-uniform appearance, the amphinema, is followed by a stage, the pachynema, in which all of the threads become uniform in size (fig. 4). During these preceding stages there has been a pairing of the threads.

The pachytene threads continue to contract and thicken until the individual chromosomes can be seen. When the stage of diakinesis is reached, the rather elongate chromosomes may be seen in close approximation, first at various sections and later along their entire length until they appear as one body. The diakinesis chromosomes are at first arranged around the periphery of the nucleus, but they later lie scattered throughout the nucleus (fig. 5). As the chromosomes

move toward the equatorial plate, they contract further. A polar view of the plate at this stage shows thirteen rounded, darkly stained bodies (fig. 6). These bivalent chromosomes exhibit no characteristics by which they may be distinguished from each other.

At the time of the metaphase of meiosis I, the microsporocytes are almost completely separated from each other and from the tapetum. However, remains of the old cell walls persist in many instances. The tapetal cells, which during synizesis remained strikingly intact, begin to show evidences of separating by the contraction and separation of their cytoplasm from the cell walls. The cell walls of the tapetal cells remain adjoined. The nuclear membrane at metaphase has completely disappeared, and well defined spindle fibers may be seen (fig. 7).

At the beginning of anaphase I, the bivalent chromosomes separate and begin to move toward the poles of the spindle (fig. 8). All members of the chromosome set do not move in a parallel fashion; certain chromosomes seem to separate and move toward opposite poles before others are parted. Many early anaphase stages may be observed in which at least one pair of chromosomes has separated in advance of others. Occasionally two or more pairs appear to move ahead of the others. However, no systematic pattern for proceeding to the poles could be observed because of the impossibility of distinguishing one chromosome from another. As the chromosomes separate at the equatorial plate and move toward the poles, they assume no characteristic V or U shape in relation to the attachment of the spindle. Instead, the parting chromosomes appear to retain their spherical shape in most cases. At times the chromosomes appear as short, thick rods, in which case the spindle attachment appears to be terminal.

The univalent chromosomes reach the poles as dark-staining thick, globose bodies. The nuclear membranes of the daughter nuclei begin to form only after the chromosomes have lost their thickness and have become irregular in outline. As the nuclear membrane becomes more distinct, the individual chromosomes lose their identity, and the chromatin material now appears as small clumps or granules. The two daughter nuclei, as seen in side view, appear oblong and flattened toward the poles of the cell. Spindle fibers persist between the two daughter nuclei (fig. 9).

In none of the cells observed in interkinesis was the chromatin material seen to form a fine reticulum. The finest mesh of chromatin

seen appeared to be roughly granular with strands extending between the granules. The nucleolus, which disappeared at the time of the metaphase, can not be seen during interkinesis. There is no division of the cytoplasm before the prophase of meiosis II begins.

Meiosis II

The small number of cells undergoing meiosis II, as compared with the number undergoing meiosis I, indicates that the former division is accomplished with much greater rapidity. Every consecutive stage of meiosis II could not be seen from the available material. The chromatin material of the daughter nuclei is reformed into distinct chromosomes which appear more elongate than those of the anaphase of meiosis I. At the time during meiosis II when the chromosomes can be seen, the membranes of the daughter nuclei have disappeared. Cells occur in which the anaphase of the meiosis II divisions of both daughter nuclei can be seen (fig. 10). The bipolar spindles are discernible, but the fibers of the spindle appear less distinct than the spindle fibers of meiosis I. The two divisions of meiosis II taking place in one cell seem to be, in the greater number of instances, at right angles to each other. However, occasional cells may be observed in which the divisions occur in planes which are almost parallel.

Cells in the anaphase of meiosis II may be observed in the same loculus with tetrads. In such a loculus the tapetal cells, although some separation has taken place, remain adjoined by cell walls. The tetrads are more widely scattered than were the microsporocytes, but occasionally two tetrads remain attached by the old cell wall. Some buds show all stages from synizesis to the formation of microspores. The progression of stages of the reduction divisions is acropetal with all cells in a single loculus usually in approximately the same stage.

The tetrad formed by these divisions consists of four nuclei in a globose or triangular mass of cytoplasm (fig. 11). Division of the cytoplasm of the tetrad is by furrowing. This quadripartition begins with four small furrows extending centripetally from the periphery of the cytoplasm, between the nuclei. The furrowing continues toward the center of the tetrad until four uninucleate microspores are separated from each other (fig. 12). The nucleus of the tetrad is not well differentiated, but the nucleolus may be seen for the first time since its disappearance before the metaphase of meiosis I.

The writer wishes to acknowledge the guidance and interest of Dr. Chester S. Nielsen, and to thank Dr. Herman Kurz for his encouragement and help in the field.

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PLATE I

Fig. 1. Resting microsporocyte.

Fig. 2. Microsporocyte with leptotene threads.

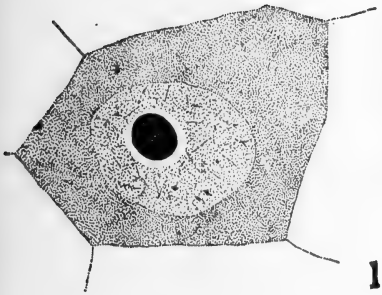
Fig. 3. Synizesis.

Fig. 4. Microsporocyte with chromatin material forming open mass of threads after synizesis.

Fig. 5. Chromosomes of diakinesis.

Fig. 6. Equatorial plate showing thirteen bivalent chromosomes.

PLATE I



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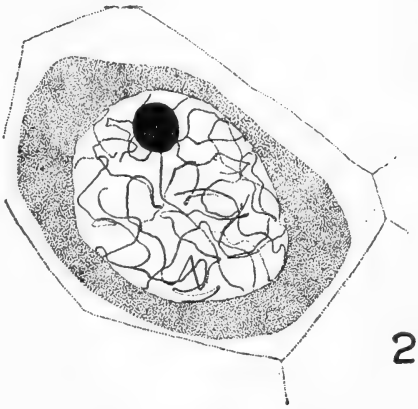

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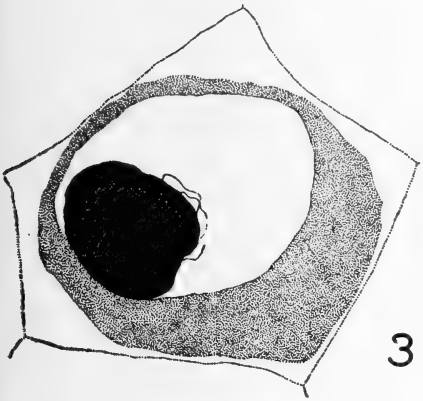

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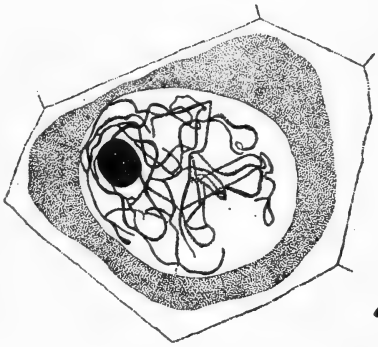

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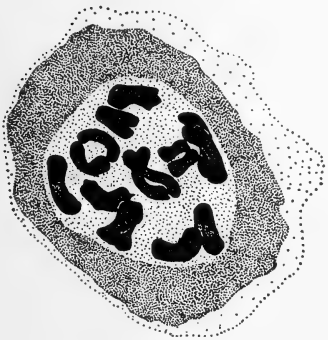

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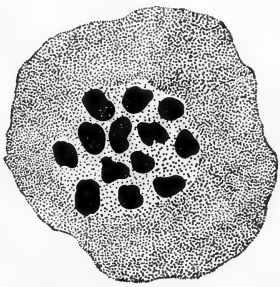

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PLATE II

Fig. 7. Microsporocyte at metaphase I.

Fig. 8. Anaphase I.

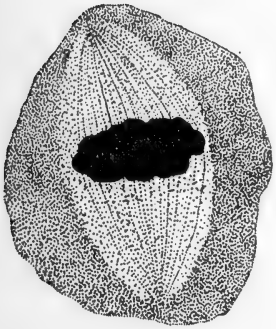
Fig. 9. Telophase I.

Fig. 10. Two divisions of meiosis II taking place simultaneously.

Fig. 11. Tetrad.

Fig. 12. Quadripartition forming four microspores.

PLATE II



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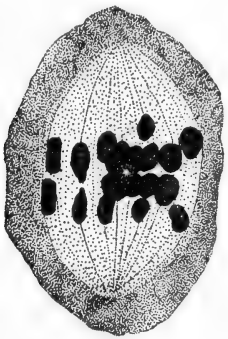

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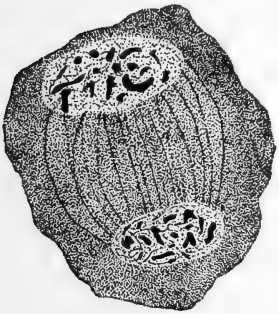

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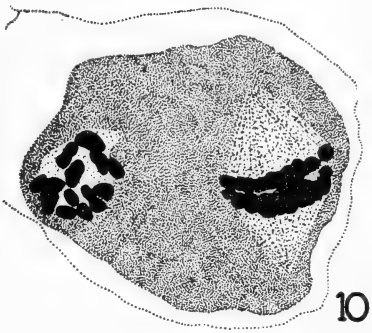

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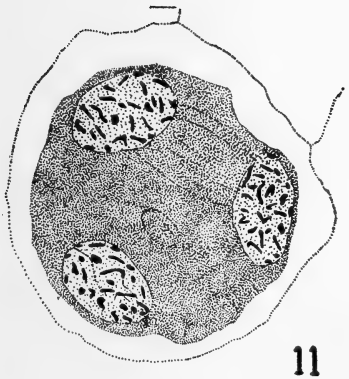

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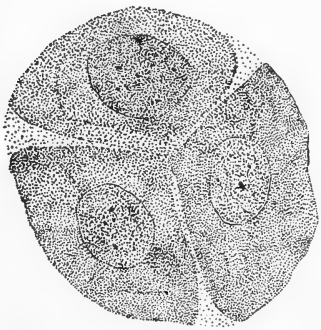


12

AGAR FROM DIGENEA SIMPLEX[1]

HAROLD J. HUMM

Digenea simplex (Wulfen) C. Agardh is a marine red alga of the family *Rhodomelaceae*. It is abundant in Florida, particularly among the Florida Keys and in bays of the Gulf coast, at least as far north and west as Apalachicola. Its general distribution is worldwide in tropical and subtropical waters. Harvey (1853) reports it from the Mediterranean, the Red Sea, and the Indian Ocean. It occurs in the China Sea and warm waters of the Pacific. There is but one known species.

In Florida and the West Indies, *Digenea* grows from two to twelve inches in height, depending primarily upon the habitat. On wave-beaten rocks (as at Bimini, Bahamas) the plants are dwarfed and spreading; in quiet bays they are often tall and bushy (fig. 1). All axes or branches of indeterminate growth are densely covered with short, determinate ramuli of about 2 mm in length so that the overall diameter of the branches is about 5 mm. The main axes, excluding the ramuli, are about 1 mm in diameter, and often become denuded toward the base. Except for the growing tips, the branches are usually heavily infested with a variety of epiphytes, especially with the slender coralline algae, *Jania* and *Amphiroa*. *Digenea* that grows in quiet bays usually accumulates, in addition, considerable quantities of fine mud among the ramuli and epiphytes. The color of the plant is brownish red, except where modified by epiphytes and accumulated sediment. The species is easily distinguished from all other algae of the West Indian region.

According to Tseng (1944), *Digenea* is a well-known drug source in the Orient. Two pharmaceuticals are prepared from it, *macnin* and *helminol*. The latter is said to be as effective a vermifuge as *santonin*, and has the advantage of producing no ill effects.

Since *Digenea* occurs in considerable abundance in Florida and West Indian waters, it was felt that a study of the agar and pharmaceutical properties of the extractives obtainable from it might eventually lead to its utilization in the Western Hemisphere. A pharmacological investigation has been undertaken by Dr. Arnold Neva, College of

[1] This investigation was carried on while the author was affiliated with the Duke University Marine Laboratory, Beaufort, N. C.

FIG. 1

Digenea simplex (Wulfen) C. Agardh X1½

Pharmacy, the University of Washington. The possibilities of pharmaceuticals from other species of marine algae are also worthy of study.

This report deals only with the agar obtainable from *Digenea.*

Materials and Methods. *Digenea* material for agar extraction was obtained from Biscayne Bay at Miami, from the Florida Keys along the Overseas Highway, and from several localities along the Florida west coast, particularly at Ozona. The seaweed was washed in fresh water and sun dried immediately after collection. Epiphytes were removed as thoroughly as was practicable. In the laboratory, the sun dried material was further dried to constant weight at 50° C. as a basis for yield data.

Since a pH of 6.0 was desirable during extraction, the seaweed was soaked in cold, dilute HCl for several hours before extraction in order to remove carbonates. It was then neutralized by dialysis in dilute KOH.

Extractions of the agar to determine yield, and determinations of gel strength, temperatures of gelation and melting, and viscosity were carried on in the same manner as described in a previous paper (Humm and Williams, 1948). After the agar solution had been filtered, frozen, and thawed, the agar flakes or chunks were placed in a volume of distilled water estimated to produce approximately a one per cent solution. This was heated until dissolved, and the concentration determined by dehydration of a 10 ml sample at 50° C. in a tared evaporating dish. Solutions of the concentrations desired for testing were prepared by adding distilled water to measured volumes or by concentrating a certain volume by heating and constant stirring. Difco "Bacto" agar was used as a standard of comparison. Solutions of it were prepared from samples that had been dried at 50°.

Results. From 10 to 15 per cent of the dry weight of *Digenea* is obtainable as agar, a low yield when compared to laboratory yields of other algae from which phycocolloids are obtained. With *Gelidium, Gracilaria,* and *Hypnea,* yields range from 35 to 50 per cent or more (Humm, 1944, 1947, 1948; DeLoach *et al.,* 1946a, 1946b).

The gel strength of *Digenea* agar compares favorably with the standard, Difco "Bacto", particularly when the concentration is above 1.0 per cent. With concentrations below one per cent, Difco agar apparently is stronger (fig. 2). Stoloff and Lee (1949) failed to obtain a gel-forming extractive from *Digenea,* probably because its

colloid does not extract unless the pH is maintained during cooking at 6.0 or slightly lower.

In preparing the higher concentrations of *Digenea* agar by evaporation, a flocculent precipitate developed as the concentration reached approximately 1.5 per cent. There is some evidence that the pre-

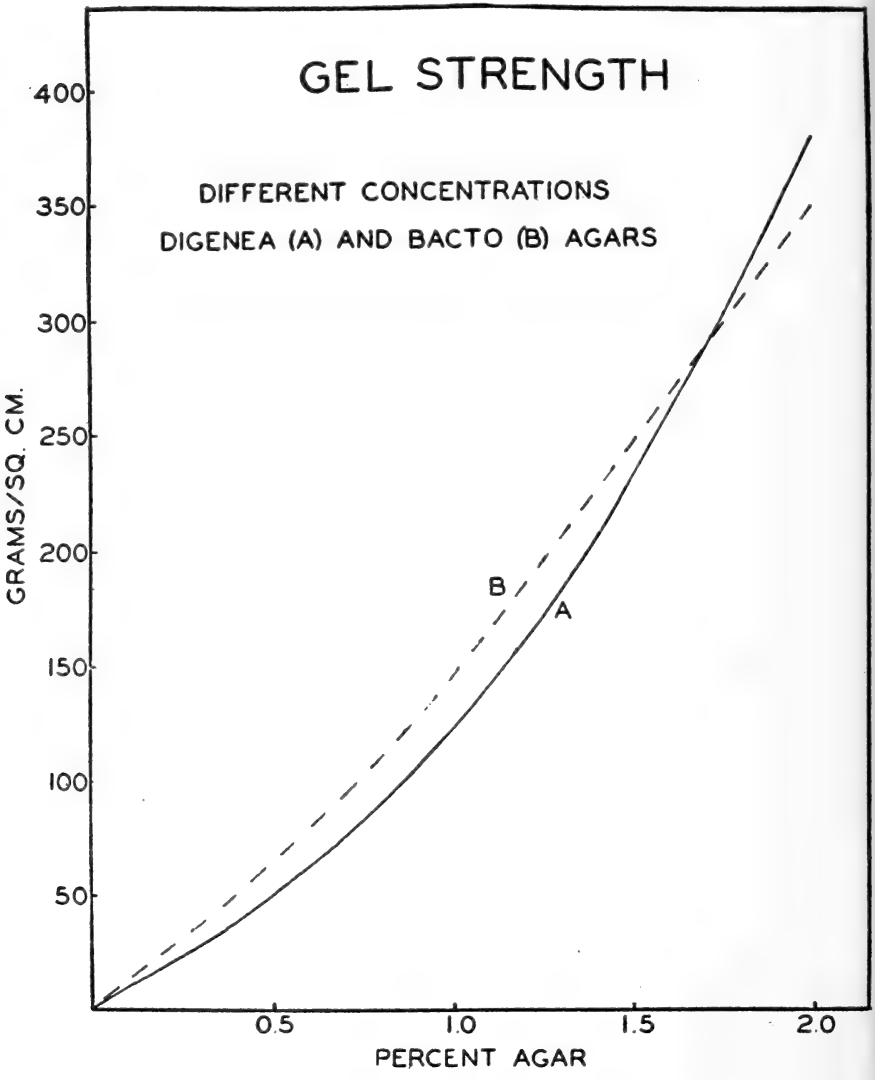


FIG. 2

cipitate is *Digenea* agar and that its solubility is lower than that of agar from other sources. However, as the maximum solubility is approached, the gel strength rises sharply. Although 2.0 per cent of *Digenea* agar was present in the solution tested for gel strength, it is probable that the actual gel structure was composed of a lower concentration because a small portion had precipitated. When the 2.0 per cent gel was re-filtered and the concentration of the filtrate determined, it was found to be 1.82.

Temperatures of gelation and melting of *Digenea* agar are somewhat higher than those of Difco "Bacto", as shown in Table 1. These properties, however, are within the range required of bacteriological agar.

TABLE I

TEMPERATURES OF GELATION AND MELTING OF DIGENEA AND DIFCO BACTO AGAR. FIGURES ARE DEGREES C.

Concen. Per Cent	Temperatures of Gelation		Temperatures of Melting	
	Digenea	Bacto	Digenea	Bacto
1.0	38	33	74	65
1.5	39	34	76	70
2.0	41	36	78	76

A comparison of the relative viscosity of 1.5 per cent solutions of *Digenea* and "Bacto" agar is shown in fig. 3. It appears that the viscosity of *Digenea* agar is slightly greater at temperatures above 45° C., but that the viscosity of the two is about the same below this temperature and until incipient gelation occurs.

Discussion. Because of the low agar yield, it is doubtful that *Digenea* will prove to be of economic value as a source of agar alone, even where it occurs in great abundance. If, however, a valuable vermifuge or other pharmaceutical can also be obtained from it, the species might prove to be useful.

In addition to the disadvantage of a low yield, difficulties will be encountered in washing the dried material and in maintaining the pH at the proper level because *Digenea* accumulates mud among its numerous, hairlike, determinate ramuli (calcareous mud in the southern part of its range), and because it supports a dense growth of epiphytes, many of which are calcareous.

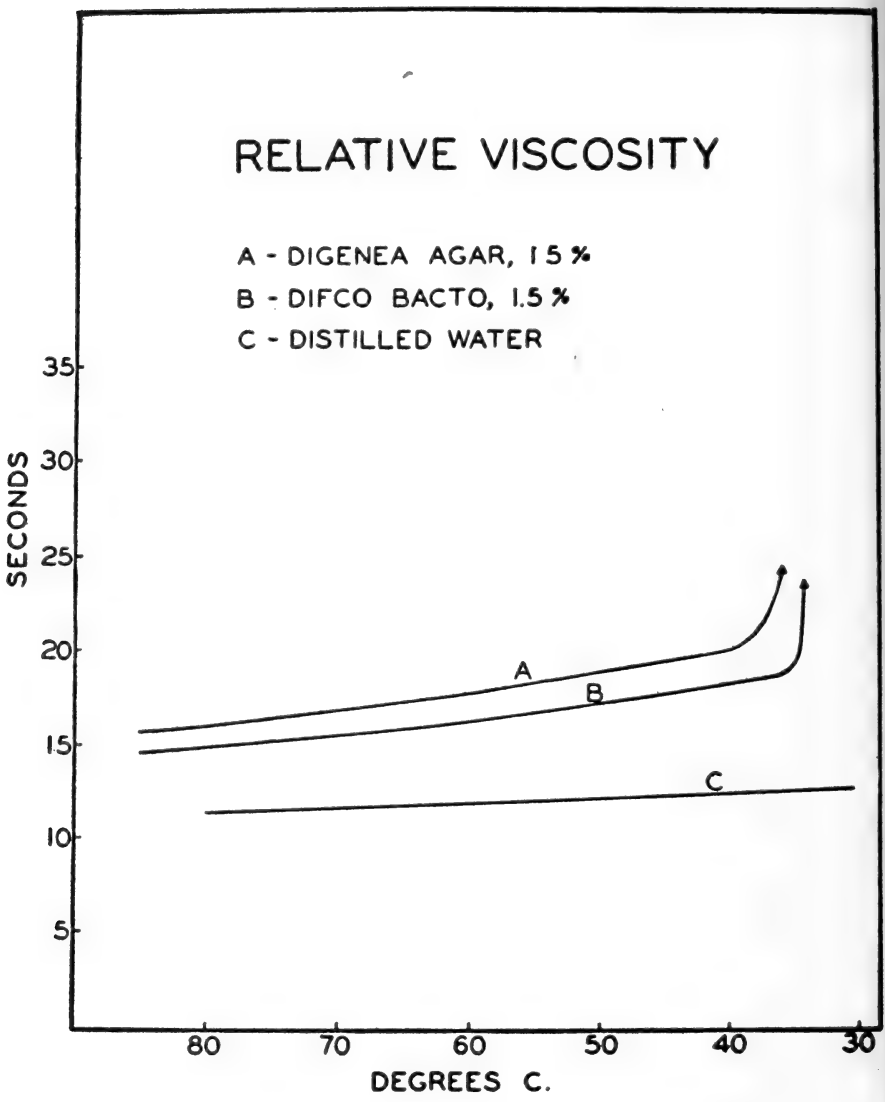

RELATIVE VISCOSITY
A - DIGENEA AGAR, 1.5 %
B - DIFCO BACTO, 1.5 %
C - DISTILLED WATER
SECONDS
35
30
25
20
15
10
5
A
B
C
80
70
60
50
40
30
DEGREES C.

FIG. 3

RELIABILITY OF GROWTH RINGS IN MAGNOLIA GRANDIFLORA L. AS INDICATORS OF AGE

BRUCE C. FLANDERS

I. INTRODUCTION

General public interest has been aroused by majestic old trees in various parts of the United States, some of which, on the basis of number of annual rings shown in cross section of the trunk, are claimed to be thousands of years old. In a good many cases the age estimate of these trees is computed from annual growth ring counts, either from increment cores of the trees themselves or from stumps or cores of many individual trees of the same species. If the latter procedure is used, the average of the number of growth rings per inch of diameter is applied to the diameter of the tree in question. However, it is known that a number of species of trees produce additional growth rings in some seasons; hence, if the extra rings are counted as annual ones, the age of a tree may be greatly overestimated. It is now believed that the Big Cypress at Longwood, Florida, is not nearly as old as some of the estimates made which did not take into consideration the existence of false rings so common in cypress (8). Since the so-called annual rings do not necessarily represent a year's growth, it is preferable to speak of them as growth rings.

Counting growth rings is also the basis by which the age of climax forests has been estimated (15). Foresters compile reports on the amount of available lumber from growth estimates based on increment cores which, by means of the growth rings, bear witness to the age and quality of the wood (17).

A. E. Douglass (7) employed three rings to date timbers of ancient Pueblo villages in Arizona and also published an account of his work attempting to relate growth rings to sunspot cycles (5, 6). This same investigator was instrumental in influencing authorities to increase the power output of Boulder Dam during the last war. Production experts claimed that they needed much more than the existing 663,000 horsepower every hour, twenty-four hours a day, in order to manufacture the materials necessary for our participation in World War II. Hydro-electric engineers were opposed to this increased

production since they believed that the water reserves essential to performing such a feat would be dangerously depleted and that millions of people would be deprived of water. It was at this point that growth ring studies entered the picture. Some trees produce narrow rings in dry years and wide ones in wet years, so that the rainfall record of the past is fairly accurately recorded in the wood. To settle the power dispute Douglass and his co-laborers made a 10,000-mile tour of the Colorado Basin trying to discover from the growth rings in hundreds of trees whether or not the water could be replenished. At the end of the survey, which involved growth rings dating back several hundred years, it was discovered that almost twenty dry years had just passed, but that according to the growth ring record, such a drought was unusual in the last 500 years and probably would not continue. Thus, the water reserves no doubt would be restored with the return of normal rains. The result was that the accelerated power production of Boulder Dam was set in motion, and it is possible that such a step shortened the war. An interesting sideline is that the following year the Colorado Basin received an unusually heavy rainfall (1).

Growth rings have even influenced decisions in legal battles. In 1919 Texas and Oklahoma were arguing about oil lands underlying the south bank of the Red River which, in a treaty with Spain 100 years previously, had been designated as the boundary between the two states. The oil was found under lands which had been added to the south bank either by deposition or by a shift in the river's channel. Thus, in this case involving millions of dollars, it was highly desirable to establish beyond doubt the exact location of the south bank 100 years before. A count of the growth rings of many widely scattered elms and other trees, in addition to a study of the rate of development of the climax vegetation, revealed that the oil lands had undoubtedly been on the Texas side of the river for over 100 years.

In order to pursue the question of false growth rings, a preliminary investigation was made by the writer during the winter and summer of 1949 to determine if any trees in the Tallahassee, Florida, area gave indication of growth ring anomalies.

The trees investigated were bald cypress (*Taxodium distichum* (L.) Rich.), spruce pine (*Pinus glabra* Walt.), loblolly bay (*Gordonia lasianthus* Ell.), red bay (*Persea borbonia* (L.) Spreng.), southern magnolia (*Magnolia grandiflora* L.), sweet bay (*M. virginiana* L.),

southern cucumber tree (*M. pyramidata* Pursh.), Ashe's magnolia (*M. Ashei Weatherby*), bigleaf magnolia (*M. macrophylla* Michx.), cucumber tree (*M. acuminata* L.), yellow poplar (*Liriodendron tulipifera* L.), American holly (*Ilex opaca* Ait.), and anise (*Illicium floridanum* Ell.).

Sweet bay, American holly, bald cypress, loblolly bay, spruce pine, and southern magnolia presented evidence of false growth rings, but it was decided to limit the study to southern magnolia.

Of the species mentioned having false rings, all but the cypress are evergreen, a fact which may be significant as a factor predisposing to the production of false growth rings.

II. PRESENT STATUS OF KNOWLEDGE OF TREE RINGS

True Annual Rings

The practice of using growth rings of trees as age indicators presupposes that only one ring is produced each year, a fact which in the majority of cases is true. However, it has been noticed that trees at times may produce more than one ring in one growing season, or under certain adverse conditions even fail to form a ring at all (4, 9). In tropical countries with no pronounced seasonal changes growth rings do not usually occur, although they may be evident as the result of any interruption of growth.

In order to possess the proper conception of a false annual ring, it is necessary to comprehend the nature of a normal annual ring which may be expected to be formed during a growing season.

Each year a new cylinder of wood is produced connecting with and extending peripherally from the one elaborated during the preceding season. Each cylinder is taller than the next innermost sheath of wood by the length of the annual shoot. If one disregards the insertion of branches or any abnormalities in the growth form of the tree which cause it to deviate radically from a cylindrical shape, one may imagine the yearly increments of wood as being represented by a series of inverted cones graduated in size, placed one on top of the other, with their bases on the same level (fig. 1). Transverse sections taken at various levels would intercept different numbers of the cylinders, one at the top and five at the base of the tree illustrated in the figure. Thus, the number of growth rings seen in cross section decreases from the base to the tip of the tree.

An annual increment as seen in a transverse section of a stump, stem, or branch of *Magnolia grandiflora* consists of a band of early wood grading into a band of wood laid down toward the end of the season. The early wood is cream-colored to the naked eye and is composed of spirally thickened tracheids with bordered pits and vessels with scalariform perforations sculpturing the walls. The rays consist of fifteen to sixty (usually thirty-five) cells radially arranged and are from one to three cells wide.

Macroscopically the late wood appears a light reddish brown and is bounded by a more or less definite white line. Microscopic examination reveals that the tracheids become flattened tangentially, with thicker walls and smaller lumina than the early wood. Wood fibers commonly occur. In this species, which is diffuse-porous, the number and size of the vessels gradually decreases toward the periphery. The outer boundary of the growth rings consists of two to four rows of tangentially flattened wood parenchyma cells possessing very thick radial walls with numerous simple pits (18, 19).

The change in the type of xylem cells put down by the cambium early and late in the season is not a precipitous transformation. Thus, the eye perceives a gradual blending of early wood into late wood, whereas the contrast between the late wood of one season and the early wood of the next is striking. This alternation of the type of wood cells formed by the cambium is responsible for growth rings.

False Annual Rings

A false annual ring is the result of any interruption of normal growth of a tree followed by a resumption of growth within that season. Consequently, there are two or more alternating bands of both types of wood rather than the one band of early wood followed by a single band of late wood.

Types of False Rings

Some of these false rings are easily recognizable to the unaided eye or with a hand lens in that there is a band of dark wood fading into light wood on both sides (fig. 2), showing that the plant formed late growth too early in the season and had to revert to early growth again before the season actually ended (11).

A "lens" (fig. 4) is another prominent type of false ring easily

recognized according to Sampson and Glock (20) and Glock and Reed (12). It is produced by a cambium which was active only part of the way around the circumference of the tree with the result that the late wood of one year merges with the late wood of the preceding year. A lens may sometimes be considered to constitute the entire annual increment (20).

Schulman (21) states that the types of false annual rings range from extremely ill-defined ones to those that cannot be distinguished from true ones until they are cross-dated. Sharply bounded annual-like false rings found by MacDougal and later by Schulman in Monterey pine for the year 1918 illustrate the one extreme, while blotches of dark cells in early wood of large infancy rings in conifers demonstrate the quite ill-defined type.

Factors Affecting Occurrence of False Rings

The occurrence of false rings is not necessarily consistent. The factors causing the production of entire or partial extra rings may stimulate only certain portions of the cambium in one radius. They may effect only the younger parts of the tree, may vary with the locality, or may vary with the species.

AGE

Frost damage to longleaf pine in Mississippi affected usually only the one- and two-year-old shoots which then produced false rings (22).

Douglass (6) gives the following summary of the effect of age on doubling of rings in trees observed by him:

> Doubling is far more conspicuous in the earlier or "youth" rings of a tree when the trunk is rapidly increasing in size. These youth-rings are larger and less sensitive than the later rings. Of course, it is more apparent in large rings, and any tree which grows rapidly is more likely to show it. However, without specially investigating the point, one is inclined to think that young trees, being less sensitive than mature ones, are a little more certain to continue their growth into autumn and so do have more doubling than mature trees. This could be tested by the dendrograph on properly selected trees.

Glock (10) states that multiple layers are less common in the basal trunk than in the branches.

LOCALITY

Trees may be inclined to produce false rings at one site, while in another location the species may hardly ever produce false rings. For example, Sampson and Glock (20) state that ponderosa pines from the Sierras seldom had false rings, while those in the Santa Cruz Mountains were commonly found to have them.

Douglass (6) in his collection of trees for cross-dating purposes, found that the trees near Prescott, Arizona, were especially prone to have extra rings which were ordinarily easily recognized as false. However, some of the extra rings were so similar to the true annual ones that it was rather difficult to distinguish the two. Each rainy season at that location consists mainly of isolated storms. Douglass believes that these storms contribute to the formation of many false rings. He says:

> The soil on which these Prescott rings grew is a disintegrated granite which forms a very efficient reservoir, holding abundant water with little leakage. The top of Mount Wilson is very similar in type of soil, though not in climate, for it has a single rainy season in winter. Double rings are practically unknown there. At the lower levels of the Santa Rita Mountains near Tucson the soil and also the climatic conditions are again similar to those at Prescott. The trees there depend on summer rains even more than at the northern mountains and the doubling character is more conspicuous and bothersome. Thus it is seen that doubling is a local climatic effect.

SPECIES VARIATION

Not all trees, when subjected to the same phenomena which may result in the formation of false rings, respond by producing additional growth. Büsgen and Münch (3), in describing the work of Kny, state:

> In the mountain ash, pedunculate oak, and the small leaved lime, Kny found a second annul ring formed after complete defoliation by insects in June followed by a fresh production of leaves, whilst, the birch, in similar circumstances produced no double annual ring.

Douglass (6) also noted that doubling of the rings was very common among pinyon and juniper at the lower levels in Arizona, while the yellow pine in California showed rare doubling. This condition was unknown in the Douglas firs and sequoias. At another time Douglass found, in addition to the trees mentioned above, that Vermont hemlocks and north European Scotch pines which had been sent to him gave no indication of doubling. However, he found that this situation in cypress trees was very troublesome in correct dating of rings.

Causes of False Rings

DEFOLIATION

According to Büsgen and Münch (3) the formation of two rings a year is usually the result of the production of two sets of leaves, as is the case when limes and horse chestnuts develop green leaves and a few flowers in September following shedding of leaves in August. These authors also state:

> Kühn, by artificial defoliation of the horse chestnut, hazel, and mountain ash, brought about a doubling of the ring in which the boundary between the two false annual rings was formed by abnormally thin-walled cells.

Defoliation, whether by frost, drought, mature insects, or caterpillars, is given as the cause of false ring formation by several investigators (10, 24, 25).

MOISTURE CHANGES

Antevs (2) reports that it has long been known that a spell of warm weather in the autumn and a good food and moisture supply cause a resumption of growth which deposits a narrow, though typical, second growth ring outside the regular annual one.

Douglass (6) describes trees passing through spring drought followed by summer rains resulting in the production of additional growth in the fall. This wood in some instances had the color of the normal spring wood. In this case the difficulty in distinguishing this extra ring from the normal one was surmounted by the fact that the false ring faded gradually on both sides (fig. 2).

FIRE

One of the types of anomalous growth resulting from fires is the production of false rings formed only on a portion of the circumference. Craighead (4) who made observations on certain trees in California and North Carolina, states that false rings are more often the result of fire or insect defoliation than climate which usually is given as the cause.

FROST

Frost injuries to trees at Lubbock, Texas, in spring just after new growth had started, caused multiple growth rings rather frequently in the years 1932-38. Annual increments of specimens of Arizona

cypress on the campus of Texas Technological College had one to five growth rings, and a branch of western yellow pine exhibited five rings for the year 1936-37. These layers were indistinguishable from single annual increments under any magnification up to 400x. The dates established by examining the wood coincided with meteorological and vegetational records so that it was known in which years spring frosts occurred. The number of rings, then, found between the frost rings of consecutive years gave the exact number of rings formed in one year (12).

Haberlandt (13) also reports that double rings may form when frost causes growth to cease, but buds that would have remained dormant until spring open.

III. INVESTIGATION

Whorls of Branches as Indicators of Age

There are occasions when it is imperative to ascertain the age of trees in a forest under circumstances making it impossible to count the growth rings. An increment borer may be unavailable at the time, and in an undisturbed forest, lumbering operations would not have left behind stumps bearing a growth ring history. However, if the tree is a member of a species which elaborates a whorl of branches each year, the whorls may easily be counted to arrive at an approximation of the age of the trees.

It is known that certain species of trees such as spruce and white pine produce annual whorls of branches. Toumey and Korstian (23) state that the whorls of white pine, especially when the tree is growing in the open, may be recognized up to its fiftieth or sixtieth year. These authors state that if one estimates the age of a tree by counting branch whorls, he should add two to four years to the number of whorls to allow for the time the seedling was growing but producing no branches, or when those branches formed left scars too small to be noticed as the tree matures.

Instances where two whorls of branches are proliferated in one growing season have been described for the loblolly pine, shortleaf pine, and chestnut oak (23). Field observation by the writer revealed the same condition for slash pine (*Pinus elliottii* More.), and spruce pine (*Pinus glabra* Walt.). Consequently, this method is not always a reliable one for age determination.

Magnolia grandiflora frequently exhibits definite whorls of branches (fig. 11), and a survey was initiated by the author to ascertain if they were produced annually, and, incidentally, if they could be used as a check of the growth ring number.

METHOD

Saplings as tall as could be handled easily were brought into the laboratory. The whorls were counted as far down the trunk as they could be clearly seen. The tree was then sawed just below the most basal whorl. After smoothing, and, if necessary, treating with phloroglucin, the cut end was examined to see if the number of growth rings at that level correspond with the number of whorls down to that point. Also for five saplings the above procedure was repeated just below each whorl from the lowermost clear-cut one up the length of the tree to the tip. Investigation was made in the field of additional saplings, the trees being cut just below the most basal whorl.

The same treatment was given to a large fallen tree in a forest which had just been lumbered. In this case two disks several inches thick were sawed from the tree, one just below the fifteenth and the other below approximately the forty-first longitudinal growth areas. Smoothing the rather large disks was begun on a sanding machine in the University Carpentry Shop and then completed by hand, using very fine sandpaper. Furniture polish proved useful for finishing and caused the growth rings to stand out more clearly.

In addition, increment cores, obtained with a Swedish borer, were brought in from two trees in the yard of a residence at 510 Palm Court, Tallahassee. In this instance whorls were counted from the bottom up since the size of the trees required that they be climbed in order to secure the count. Borings were made just below the whorls at four levels on the trees. At the places where the borer penetrated the entire diameter of the tree, cores were taken from two directions. However, at the base of the tree where it was doubtful that the instrument could reach the pith, borings were taken from four directions in the case of the first tree, and three directions from the second.

For safekeeping the cores were secured with Scotch tape in a groove of corrugated pasteboard with the identification number of each core marked opposite the groove.

These cores later were smoothed with sandpaper, treated with furniture polish or phloroglucin, and examined macroscopically as well as with the aid of a binocular dissecting microscope.

RESULTS

The results for the five saplings may be shown in table form. The number of rings expected just below each annual whorl of branches should be one more than the whorl number, since there is usually one intervening internode between the terminal bud and the first whorl.

TABLE 1

WHORLS AND GROWTH RINGS OF MAGNOLIA 1

Whorls	Number Rings Expected Just Below Whorls	Number Rings Found Just Below Whorls
1	2	2
2	3	5
3	4	7

In this tree (Table 1), there is a discrepancy between the number of growth rings and the number of whorls. Further examination of the sapling showed two areas of terminal bud scale scars between the first and second whorls and one between the second and third (fig. 3), indicating that seasonal longitudinal growth occurred, but no branches were formed in those years. Cutting the main axis just below these areas revealed three and four rings respectively below the first two areas and six below the third. In other words, a count to the third whorl using the total of both whorls and terminal bud scale scars indicated six longitudinal areas of growth, and predicted seven growth rings to be found below the third whorl, which was actually the case.

The whorls and growth rings of the second and third magnolia saplings examined checked precisely with each other as evidenced by Table 2. In this instance, therefore, the trees produced a whorl of branches each year back to the point at which they were cut.

TABLE 2

WHORLS AND GROWTH RINGS OF MAGNOLIAS 2 AND 3

Whorls	Number Rings Expected Just Below whorls	Number rings Found Just Below Whorls
1	2	2
2	3	3
3	4	4
4	5	5

The fourth sapling, however, showed very different results as Table 3 indicates. The proper number of intervening terminal bud scale scars between the whorls was discovered to allow the investigator to expect the fifteen growth rings found below the seventh whorl.

The branches of Magnolia 5 were rather far apart for whorls, representing more nearly the usual alternate arrangement of branches, but checked with the rings except just below the fourth so-called whorl (Table 4). Sectioning between each of the branches forming the "whorl" revealed five rings just below the second branch of the whorl. This condition indicates that the branches constituting a "false" whorl were not necessarily formed during a single season.

TABLE 3

WHORLS AND GROWTH RINGS OF MAGNOLIA 4

Whorls	Number Rings Expected Just Below Whorls	Number Rings Found Just Below Whorls
1	2	2
2	3	4
3	4	6
4	5	9
5	6	10
6	7	12
7	8	15

TABLE 4

WHORLS AND GROWTH RINGS OF MAGNOLIA 5

Whorls	Number Rings Expected Just Below Whorls	Number Rings Found Just Below Whorls
1	2	2
2	3	3
3	4	4
4	5	6

Two additional saplings were investigated in the field, and by using the combination count of whorls and terminal bud scale scars the number of rings at a point below the most basal clear-cut whorl was correctly estimated.

A large fallen tree in a recently lumbered forest gave very interesting results. The tree was found lying about fifteen feet away from its stump which was approximately two feet high and eighteen inches in diameter. The total height of the tree, including the missing fifteen feet, was estimated as sixty-three feet. On the terminal part of the tree which was still intact the whorls were obvious except in two places where an odd branch appeared between two whorls. By ignoring these branches an estimate of the growth ring number to be expected at the base was thirty-nine, and by including them, forty-one. A count of the rings on the disk taken from the base of this tree totaled approximately eighty, nearly twice the anticipated number.

Farther up in the same tree, where it was estimated that sixteen rings would appear, sixteen rings were discovered, making it apparent that the discrepancy between the number of whorls and growth rings occurred in the older parts of the tree.

In both the cultivated trees the very tip of the main axis could not be seen from the ground because of dense foliage, and the fact that the terminal branches would not bear the weight of the climber prevented his being able to reach the top. However, it was certain that at least one longitudinal growth region remained above the vision of the climber, who could see the top but was not able to discern the exact number of terminal bud scale scars present. Since no

errors in growth ring counts as compared with the number of terminal bud scale scars toward the apex of the tree had been noted in any other trees, it was reasonably certain that the growth rings in this tree should check with the bud scale scars in the terminal part of the crown. Because the climber reached so near the top of the tree it was doubted that he missed, at the most, more than three regions of terminal bud scale scars, and possibly only one. If, then, one year was added to the number of longitudinal areas counted in climbing from the bottom, by counting from the top down it was found that the two topmost cores of the first tree and the upper one of the second showed the number of growth rings to be the number estimated. If two or three were added to the total number of areas counted, the number of growth rings in the cores was two or three smaller than the estimate, a situation not likely in this species known to produce extra rings. The lower cores did not reach the pith.

CONCLUSIONS

Whorls of branches in *Magnolia grandiflora* do not offer an entirely reliable means of estimating age. Observation revealed that each year's growth is not always marked by a branch whorl, although in those years the longitudinal increment is bounded by terminal bud scale scars. In saplings where whorls as well as terminal bud scale scars are visible, the correct age down to the most basal point at which they are evident may be ascertained by a combination count of whorls and bud scale scars. However, as the tree matures, some of the lower branches may drop off, and the bud scale scars at the base or between the whorls, if the tree is sufficiently large, may be obliterated by the expansion of the bark. The only other means of estimating age, with the failure of whorl counts, is by recourse to a count of the growth rings.

Reliability of Growth Rings as Indicators of Age

This phase of the work was undertaken to determine if, regardless of the presence or absence of a natural check of a growth ring count, there are any abnormalities readily noticed in gross examination of the growth rings of this species which might cause confusion in estimating age.

MacGowan (16) reported that he had to discard cores of magnolias in a growth rate study of trees in the Tallahassee vicinity because of

multiple rings, and Kurz (15) also had difficulty in estimating the rate of growth of magnolia-beech climax forests for the same reason. MacGowan states:

> The annual ring in this tree contains one to several fine parallel white lines, the annual sets of lines being usually well separated at some part of the circumference, but in other places they may spread apart and approach the lines belonging to next year's growth so closely as to be indistinguishable from them. Several multiple rings thus spread out may appear to be the growth of a score of years.

METHOD

Examination for evidence of abnormal growth ring structure was made on the following, some of which were mentioned previously:

a) five saplings from shady-moist woods
b) disks from large tree in lumbered forest
c) twelve stumps in lumbered forest
d) cores from trees at 510 Palm Court, Tallahassee
e) branches from crowns of three partially buried trees at Beacon Hill, Florida, dune area.

Treatment of the trees mentioned in a), b), and d) was described in the preceding section.

The stumps in c) required no treatment at all as the rings were clearly visible to the unaided eye. The twigs from the trees in e) were sawed up into the desired segments, smoothed with a knife, and treated with phloroglucin before examining.

An application of phloroglucin to the stump which appears in fig. 12 afforded better photographic results than would have been obtained with no treatment.

RESULTS

a) "Lenses" of additional growth were found in all five of the saplings. One sapling seemed to have a lens on the outer ring composed entirely of greatly lignified summer wood, but with no definite line marking the boundaries (fig. 5). Some of the remaining specimens had easily visible white bands delimiting the lenses. Others possessed complete circles of narrow white bands very close to the true annual rings.

b) A single ring diverged into two or three bands at several places on the larger disk from the big tree.

c) All of the stumps examined showed lenses (fig. 4) or diverging rings (fig. 12), in all instances sufficiently wide to be intercepted by an increment borer.

d) All cores from the cultivated trees showed extra white bands either within the spring wood or on both sides of the contrasting summer wood (fig. 6) which appeared a dark reddish brown.

e) The dune trees revealed only a few very doubtful suggestions of lenses in addition to the expected annual rings which were quite narrow on the average.

CONCLUSIONS

Gross examination of magnolia specimens of various ages and from different habitats gave ample indication that an error in estimating the age of trees by counting the growth rings could be made. If the entire transverse section could be examined, the boundaries of the lenses could be easily determined. The actual total number of rings for any particular cross section in this work was obtained by counting the single part of the ring and ignoring the lens. If the lens were counted as a separate year, the number did not check with an external count of the longitudinal growth areas. However, if the entire diameter cannot be observed, as would be the case if increment cores were relied upon for an age estimate, several lenses could be intercepted with the result that the tree might be judged several years older than it actually is. Confusion might result also from the thin rings just inside or outside the true annual ring.

The occurrence of lenses on the large disk from the big tree in the lumbered forest accounts for only three or four additional rings, so that the great discrepancy between the number of whorls and growth rings may be explained by the presence of entire false rings in addition to the normal ones. Another possibility is that there might have been now obliterated terminal bud scale scars between the whorls in the basal part of the tree, so that the age was underestimated.

The cores from the cultivated trees showed a distinct color difference between the true and false rings which might be used as a criterion to distinguish the two. The former were a light, reddish brown, while the latter were definitely white. If this characteristic were found to be constant, the difficulty could be overcome by counting the dark rings and ignoring the light ones. However, the boundaries of all the rings in the stumps which were observed were of the same white color. It is possible, though, that some of the rings were dark when the tree was freshly cut and that oxidation was responsible for a color change.

Douglass (6) believes that false rings should not be considered un-

common in trees which grow rapidly. The dune trees were directly facing wind, sand, and salt spray from the Gulf of Mexico and were slow-growing as the short internodes and narrow growth rings testify. Thus, it may be that because of the extremely adverse conditions under which they were growing, they were not so susceptible to the conditions causing the production of false growth rings in specimens of this species on different and more favorable sites.

Microscopic Differentiation Between True and False Rings

METHOD

When the presence of a lens or one to several thin rings was noticed in gross examination, sections were prepared for microscopic study by sectioning on the sliding microtome. The sections were made as thin as possible to include the entire transverse area at that particular location, but it was impossible to cut the sections at a uniform thickness because they curled badly. A staining combination of safranin and Delafield's haematoxylin was used following the schedule given by Johansen (14), modified for this work.

The binocular dissecting microscope proved an excellent aid for study of entire sections. More detailed observation was done with a microscope having a 10x ocular with 4mm and 16mm objectives.

Rather thick radial sections were prepared primarily for gross examination by dehydrating and staining before mounting them in piccolyte. Cover slips were not heavy enough to prevent these thick sections from curling, but mounting them between two slides obviated that difficulty.

RESULTS

The peripheral boundary of a true annual ring consists of several rows of tangentially flattened wood parenchyma cells contrasting sharply with the thin-walled tracheids and tracheae proliferated the following spring. This description, according to Record (19), was corroborated by microscopic examination in the present work, and the appearance of the false rings was compared with the appearance of the true ones as described.

The presence of a lens can hardly be overlooked in a thin, stained section for its boundaries are usually clearly marked by tangentially flattened cells which retain varying amounts of the haematoxylin. The

occurrence of simple pits in the walls of the cells indicates that they are parenchymatous. Fig. 7 illustrates diagrammatically the structure of a lens as it begins to diverge. Just to the left of area 13 the normal condition of the growth ring prevails whereby approximately three rows of wood parenchyma delimit the ring. These rows of parenchyma, varying only slightly in thickness continue around the entire circumference of the stem. Area 13 shows the diverging point of two bands of parenchyma, the divergent band continuing over half-way around the stem and merging back into the band three cells wide, thus forming a lens. There are one to two rows of tracheids between the two bands at area 13 as a detailed drawing of that area shows in fig. 8. Between areas 13 and 14 two more sets of diverging parenchyma bands occur. The first of these bands is seen toward the inside of the band which diverges from the three rows of parenchyma at area 13. This band extends for a very short distance, then disappears. The second band diverges toward the outside of the three rows of parenchyma and extends well beyond the field illustrated in the diagram, though not so far as the very outer band which began to diverge at area 13. The drawings in figs. 9 and 10 were taken from areas 14 and 15. As the lens enlarges, the number of radial rows of tracheids between the two rows of parenchyma within the indicated areas increases to six at area 14 and to nine at area 15, the widest part. A few tracheae were noticed also.

The thickness of the tracheid walls, the smaller number of tracheae, and the fact that there is no bulge of cells into the springwood of the next year seem to indicate that the lens was formed not in the spring of the following year, but late in the summer of that growing season, or possibly even in the fall or winter.

In Magnolia 2-4 (fig. 5) a lens separated from the true annual ring by a scanty band of parenchyma reaches a maximum width which actually is greater than that of the true annual ring.

Macroscopically the false rings appear fully as sharply defined as the annual ones. However, microscopic examination reveals that the gradation from terminal parenchyma of a false ring into the tracheids and tracheae produced before the actual end of that season's growth is not so sharp as the gradation of terminal parenchyma of a true annual ring into the spring wood of the next year.

In one section made from a dried chip found near a magnolia stump, there appeared before staining four thin white bands definitely sep-

arated, but quite closely appressed. After staining, the banding was not as clearly visible to the unaided eye, there seeming to be one very thick band of late wood. It was easy, however, to discover the bands with the aid of a microscope and to ascertain that they were parenchymatous. The wood elements between the bands of parenchyma consist of tracheids and tracheae, thereby indicating that they are practically identical structurally with the true annual rings. Nevertheless, the narrowness of some of these additional growth layers and the slightly thicker walls of the tracheids might lead to the assumption that they are false rings.

CONCLUSIONS

Careful examination of microslides revealed that there is no significant anatomical difference between the true and false growth rings of this species, except possibly that the walls of the tracheids composing the false rings are rather thick. Further investigation is necessary before judging that thick-walled tracheids are always typical of false rings in this species. The boundary of a false growth ring is composed of wood parenchyma as is that of a true annual ring. Hence, if a false ring becomes wide enough, it may be easily confused with a true annual ring, especially if vessels are present within the extra ring.

Examination of the radial sections revealed nothing of sufficient value to aid in the differentiation of the true and false rings.

IV. SUMMARY

1. Saplings and large trees of *Magnolia grandiflora* were examined to determine whether or not the formation of branch whorls in that species is annual.

2. Increment cores, stumps, and transverse sections of small trees were investigated to discover if there are growth ring anomalies readily visible in gross structure that might cause confusion in counting the rings.

3. Microscope slides were prepared of transverse and radial sections which showed false rings macroscopically. The purpose of this phase of the work was to ascertain if there is microscopic differentiation between the true and false rings.

The following conclusions were reached:

4. A count of branch whorls is not a reliable means of estimating age in *Magnolia grandiflora.*

5. A combination count of terminal bud scale scars and whorls reveals the age of saplings down to the last point at which the scars and whorls are discernible. Thus, this method is not effective for old trees except at the terminal part or in the branches.

6. An error in counting growth rings may easily occur if the entire transverse section is not examined because of the prevalence of false annual rings in the form of lenses and diverging rings. This factor eliminates accuracy of counts from increment cores.

7. In macroscopic examination false rings are, in most cases, as clearly defined as the true annual rings.

8. Microscopically, the contrast is less sharp between the terminal parenchyma of a false ring and the tracheids and tracheae produced before the season ends than is the gradation between the terminal parenchyma of a true annual ring and the early wood of the next year.

9. Beyond the slightly greater thickness of the walls of tracheids composing the false ring, there is no significant anatomical difference between the true and false growth rings. Both consist of tracheids, tracheae, wood fibers, and wood parenchyma.

10. Examination of radial sections revealed nothing of sufficient value to aid in the differentiation of the true and false rings.

11. The almost complete lack of false rings in the trees from a sand dune area seems to indicate that the tendency to produce false rings may be due to local climatic conditions.

Acknowledgments

The writer is indebted to the following members of the Department of Botany, Florida State University:

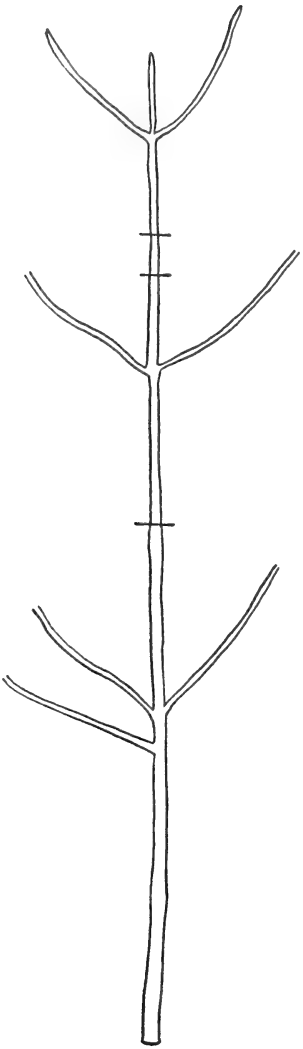
Dr. Herman Kurz, for suggesting the problem and guiding the work toward its solution; Dr. Ruth S. Breen, for her assistance in interpretation of microslides and valuable suggestions as to the writing of the paper; and Kenneth A. Wagner, who prepared both of the photographs appearing in the paper.

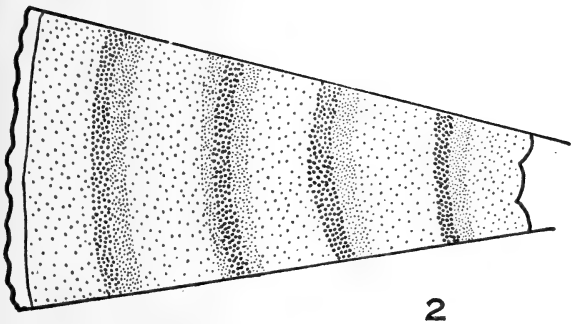
V. PLATES

EXPLANATION OF PLATE I

1. Diagrammatic representation of longitudinal and transverse aspects of growth rings of a five-year-old tree. Proportion greatly exaggerated in longitudinal diagram.
2. Portion of transverse section of a three-and-one-half-year-old tree. Light stippling represents spring wood; medium stippling, early summer wood; dark stippling, late summer wood. Third ring from center is double, consisting of a "false" ring which has early summer wood on both sides of the late summer wood, and a normal band with early summer wood only on the inner side of the late summer wood.
3. Diagram of a seven-year-old sapling with three branch whorls, showing that the whorls are not annual in this tree. Lines crossing main axis indicate areas of terminal bud scale scars, marking longitudinal growth regions of years in which no branches were produced.

1





2

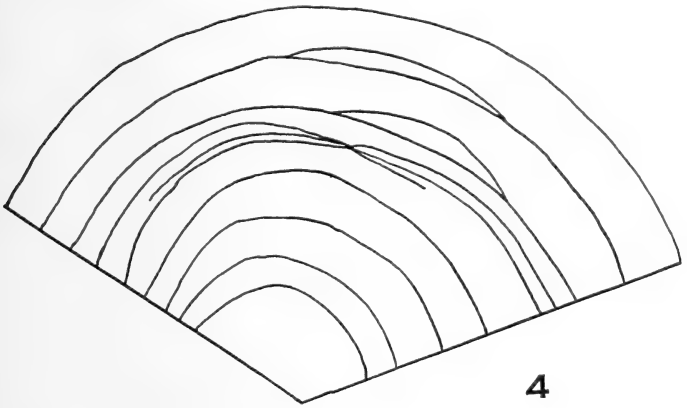
3

PLATE I

EXPLANATION OF PLATE II

4. Diagram of growth rings on portion of a stump in a lumbered forest. A "lens" appears on the second and third rings from the outside. The fourth from the outer ring shows diverging rings, some of which disappear abruptly after extending for a short distance.

5. Bioscope diagram of Magnolia 2-4. Section taken from four-year-old portion of tree. Bark is not included in the diagram. Stippled areas represent false rings in the form of lenses, the lens on the outer ring being wider than the true annual ring.



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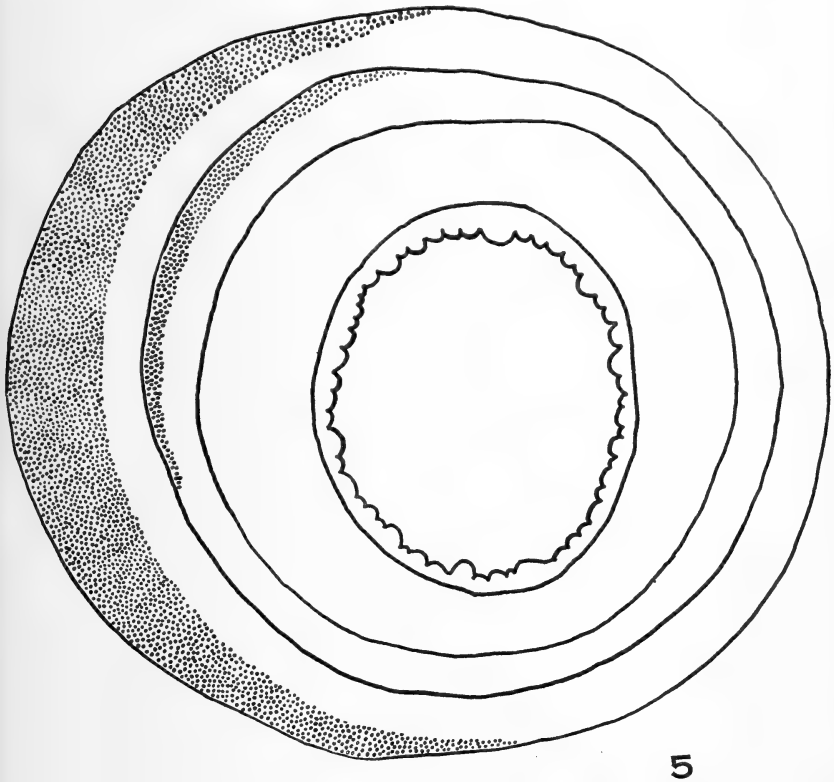

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PLATE II

EXPLANATION OF PLATE III

6. Diagram of increment core from a cultivated magnolia. Solid lines represent true annual rings. Broken lines indicate false rings which were thin white lines.

7. Diagrammatic representation of a compound false ring, or lens. Double and triple lines represent wood parenchyma which marks lens boundaries. Area 13 shows diverging point of primary lens. Detailed cell drawings of areas 13, 14, and 15 appear as figs. 8, 9, and 10 respectively.

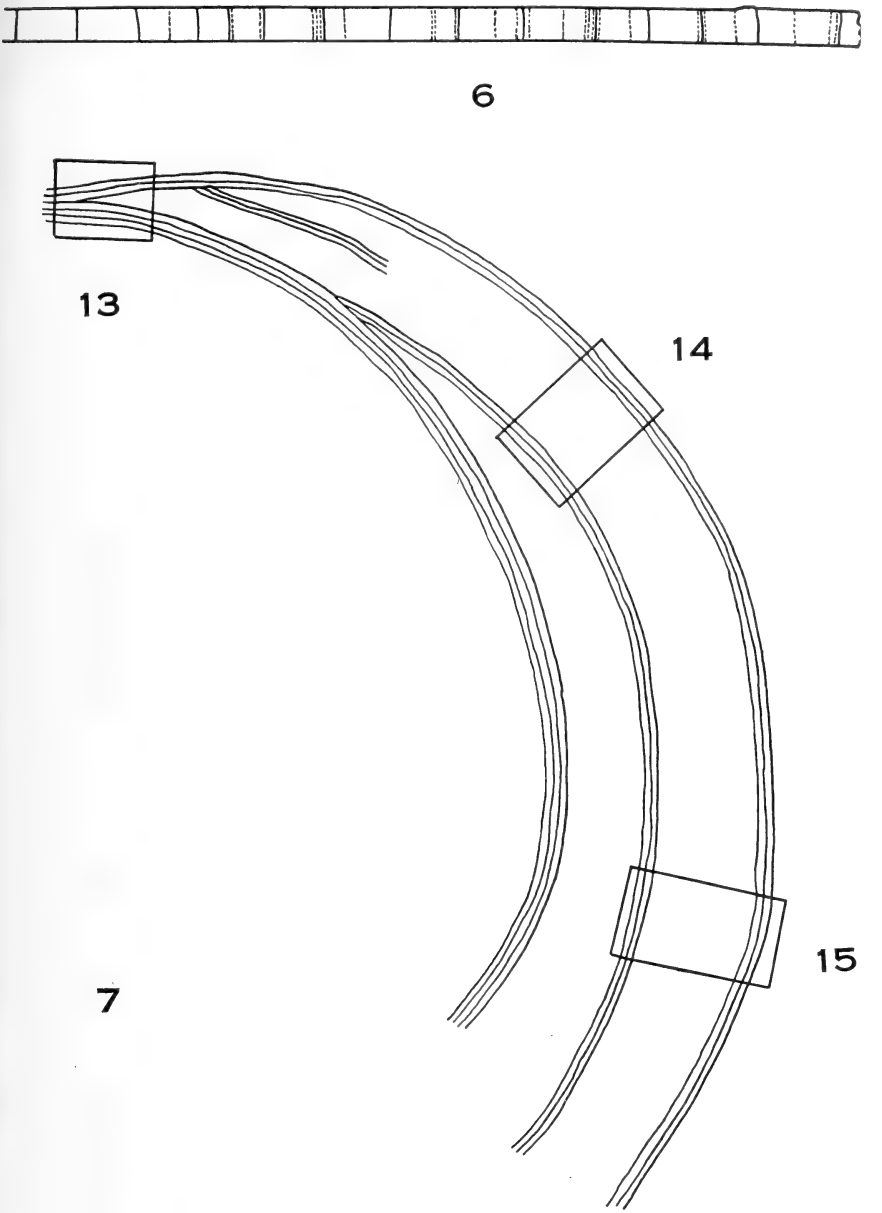

PLATE III

EXPLANATION OF PLATE IV

8. Cell detail of area 13 in fig. 7. Wood parenchyma cell walls shaded. One to two rows of tracheids appear between bands of parenchyma.

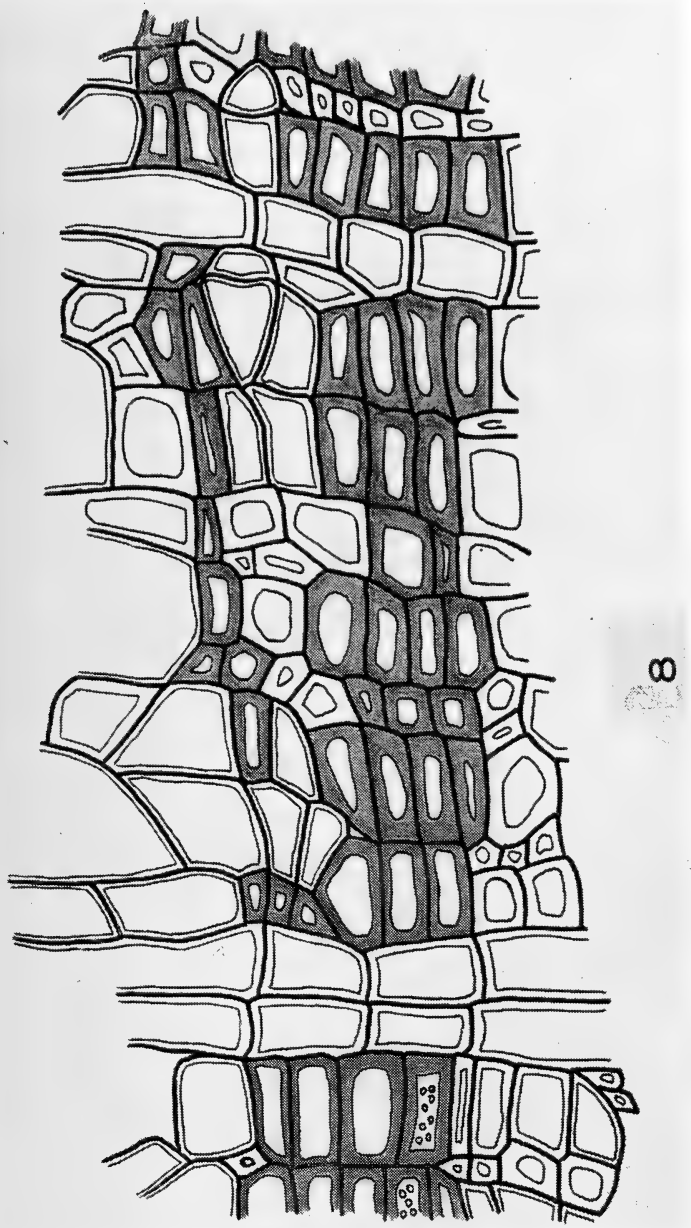

PLATE IV

EXPLANATION OF PLATE V

9. Cell detail of area 14 in fig. 7. Wood parenchyma cell walls shaded. Six to eight rows of tracheids, fibers, and a few tracheae between bands of parenchyma.

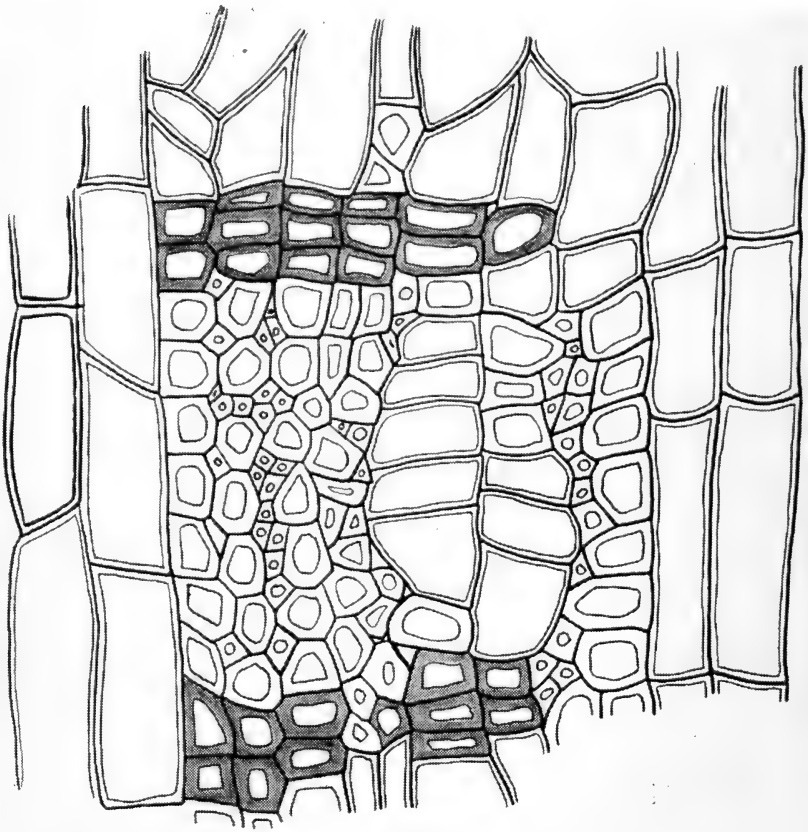

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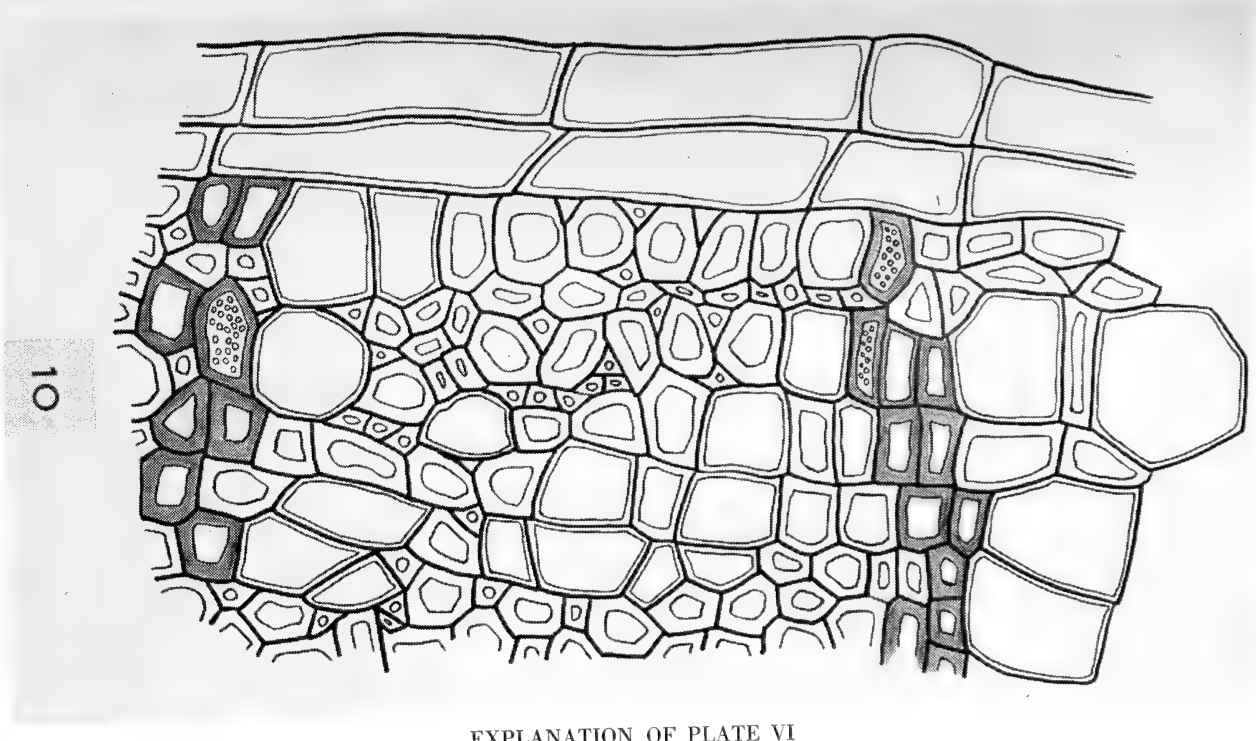
PLATE V

PLATE VI



EXPLANATION OF PLATE VI

10. Cell detail of area 15 in fig. 7. Wood parenchyma cell walls shaded. Differentiation of the tissue types of a normal ring in the false ring is complete.

PLATE VII

EXPLANATION OF PLATE VII

11. Photograph of portion of tree showing whorls of branches. Author's arm and hand may be used to estimate actual size of tree.

PLATE VIII

EXPLANATION OF PLATE VIII

12. Photograph of portion of stump in lumbered forest. Additional rings may be seen to diverge from several single rings. Critical areas marked by arrows.

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THE MATHEMATICS THAT SCIENCE STUDENTS NEED[1]

HAROLD C. TRIMBLE

The question "What mathematics do science students need?" keeps coming up. The college undergraduate soon discovers a difference between the points of view of his physics teachers and his mathematics teachers. In the graduate school he meets the mathematicians and the appliers of mathematics. He senses a class-consciousness between these groups. He begins to wonder what effects these divergent views about the values to be found in mathematics have upon the mathematics offerings of the high schools.

The value-systems of high school teachers of mathematics are influenced directly or indirectly by at least three groups of people:

(a) the college teachers of mathematics
(b) the college teachers of science
(c) the professional educators.

The high school teacher looks back into his own college experience. Often he adopts a system of ideas from his favorite professor. As time goes on his ideas are modified as he uses textbooks, listens to convention lectures and/or the like. These textbooks, speeches, etc., again reflect the ideas of college people, who may be roughly classified as mathematicians, scientists, and educators.

With this in mind, it is disappointing to examine some of the oversimplified answers given to the question "What mathematics do science students need?" An answer like "All they can get" may suit the natural bias of the mathematician. Yet much of school-mathematics contributes little to the background of a physical scientist. Another common answer takes the form of a listing of courses by name: first and second year algebra, plane and solid geometry and trigonometry, for example. Yet a little reflection would place portions of elementary statistics ahead of much of the conventional material from plane geometry.

Some educators come to resent the very existence of the boys and girls who claim they want to study science. The apparent needs of these boys and girls for "rigorous" work in mathematics seem to interfere with the apparent needs of the other boys and girls for "down-to-

[1] Presented at the annual meeting of the Florida Academy of Science in December, 1949.

earth" courses. They admit the importance of giving potential scientists a running start. Yet they rebel against doing this at the expense of all the rest of the boys and girls in high school.

The answers that college teachers give to the question "What mathematics do science students need?" weigh heavily, for these college teachers train the next generation of high school teachers. Their answers are often taken at face value by adult, practicing teachers. Whether they like it or not, they speak with authority.

This seems to justify a rather careful analysis of the question by college teachers. Perhaps it justifies this paper aimed to suggest a basis for such an analysis.

A short list of common fallacies in mathematics instruction is given first. The reader may use this list to focus his thinking for a positive approach to the question:

(1) Mathematics should not be learned as a set of conditioned reflexes. Whether it is arithmetic, algebra, or geometry, it is not much good unless it gets above the automatic-response level. Of what use is it to have a boy work efficiently with logarithms in a trigonometry class, yet prove unable to apply logarithms to calculations in a physics course that meets the next hour? Experience has shown that the sort of learning that operates only in a narrow context is rapidly lost by forgetting. The notion that the medicine is effective if and only if it tastes bad is pure superstition. If mathematical learnings are to be worth while they must do more than force boys and girls to follow well-worn mathematical forms. These learnings must be applied to problems that concern the boys and girls. They must become tools for getting results that seem worth while. This appears to throw out the over-simplifications of taking all the mathematics offered, and taking the courses merely by name. A satisfying answer must be more subtle.

(2) Mathematics should not be learned as a dramatic success, about the details of which the student is vague. Some students enter college courses in science able to verbalize about Einstein's theories but unable to add common fractions. Mathematics taught like social studies (or like some general science courses) misses the point. At least for the science student, mathematical learnings must provide a kit of tools. He needs to know more than the list of uses to which mankind has put these tools. He needs to know also how he himself can put these tools to work.

(3) Mathematics should not be learned as a vocational subject. Suppose for the sake of argument that any representative group of science teachers act as a committee to list the things a freshman science student needs to know about mathematics. They could arrange these topics in order and try to get them taught that way in high school. One suspects that the resulting program would end up about where the old-fashioned vocational shop program did. The boys learned how to make a mortise and tenon joint but never found out that its purpose was to put furniture together. At most the boys learned the parts without ever glimpsing the whole. The creative possibilities were lost.

The failure to learn the components in their relationship to the whole relegates the learner to the role of a follower. He needs someone to give him the blueprints. Then he can go along applying his separate skills. But what good are science students who know their mathematics only at the pattern-following level?

Perhaps this list of "should nots" is long enough to serve its purpose. Perhaps it is time to begin listing some "shoulds." If mathematics learning should not be a set of conditioned-reflexes, words and fury signifying nothing, or specific vocational training, what should it be? Here are some suggestions offered as thought starters:

(1) Science students need more problem-centered teaching in mathematics. It probably requires more creative energy, and much more know-how about the learning process than we teachers now possess, to begin presenting mathematics entirely through broad problems. But mathematics teachers can begin soon to use broad problems for introductory units and for summary units. They need the moral support of the college teachers of mathematics and science to encourage them to try it. Perhaps a few examples will serve to clarify the concept of "broad problems" in mathematics:

(a) A problem like "How many hairs are there on the back of my hand?" leads quickly into some useful elementary statistics. It might be used to introduce a unit on statistics by making the boys and girls aware of the need for statistical counting. In such a unit the recognition of the need for averages, sampling techniques, and the like is a first step toward good learning.

(b) A problem like "How fast can I throw a baseball?" leads quickly into the algebra of formulas. Galileo gave students of physics an easy way to measure this speed with a stop watch. Throw a ball

vertically into the air. Use a stop watch to time its flight. Then calculate the "muzzle velocity" by the formula $v=32\frac{(t)}{2}$. To get the maximum height of the ball, use the formula $s=16(t/2)^2$.

(c) A problem like "Who is the most powerful boy in this class?" might prove interesting. It would be an excellent choice for summarizing a unit on the language of variation. Surely it would be better than the sort of "review for semester exams" that is common in high schools. Suppose one used a stairway with a 12-foot rise. Then the effective horse power of a boy climbing the stair is $P=\frac{12W}{550t}$, where W is his weight in pounds and t his time in seconds. The concept, P varies directly as W and inversely as t, becomes lively in terms of the physical prowess of heavier and lighter boys, of faster and slower boys.

Such problems as these are not hard to find. The natural sciences, the scoring of athletic contests, and the planning of buildings provide opportunities, seldom realized, for working with live numbers. The teacher who can lead boys and girls to use the language of mathematics in a creative way to help unravel real problems is doing problem-centered teaching.

(2) Science students need mathematics teaching that brings arithmetic, algebra, and geometry closer together. Their progress is impeded when mathematics is purified into compartments. Science students must bring ideas from *all* the fields of elementary mathematics to bear upon a science problem.

Incidentally this solves many of the teaching problems within the field of mathematics itself. It has been found that students often forget arithmetic while they are taking algebra. This is rather fantastic when one considers the opportunities for meaningful drill in arithmetic that a lively algebra course provides. Surely a course in algebra should shed new light on meanings in the field of arithmetic; because algebra is, after all, generalized arithmetic. One cannot teach algebra in a meaningful way except by relating algebraic methods to the corresponding methods in arithmetic.

(3) Science students need to explore useful mathematical topics partially before these topics can be taught in a mathematically finished way. General quadratic equations are very useful to a few people. Pure quadratics like $16t^2=75$ are much more widely used. The mathematics teachers often take a useful topic and make it

pedantic by carrying it further than anyone but another mathematics teacher would care to go.

(4) Science students should get a few big ideas rather than an impressive miscellany of black-type, textbook rules from a course in mathematics. These few big ideas (like "There are two ways to compare numbers—by difference and by ratio. Each way has peculiar advantages. Sometimes you need the one; sometimes you need the other; and sometimes you need both to state a sensible comparison.") should be well digested. They should apply to a wide variety of problems. They should be tools ready for use in new situations that demand creative effort.

Perhaps enough has been said to make the simple thesis of this paper clear and plausible: *Science students need the same mathematics everyone else needs; only they need more of it.*

One fails to discover any serious conflict between the mathematical needs of potential scientists and other boys and girls in junior and senior high school. At this level of their development the potential scientists need live mathematics just as much as other boys and girls do. As things now stand, many able candidates are lost to mathematics and to science because they are not docile enough to follow the barren path that is prescribed. Sometimes men like Galois do creative work in mathematics even after they drop out of school as failures in mathematics.[2] Sometimes an Einstein finds out for himself that there is more to mathematics than a dull secondary-school teacher would lead you to believe. But one suspects that many likely candidates are lost.

The emphasis should shift from trying to make science students take specified topics or courses to trying to get the mathematics teacher to give science students the "more mathematics" that they need in the form of enrichment materials geared to their interests.

The proportion of science students in mathematics classes rises each year beyond the ninth grade. In most Florida schools mathematics becomes elective after grade 9. This makes it easier to build a program that is suited to science students yet does not exclude other students.

College teachers of science should continue to think about the mathematical needs of science students. They have a social responsi-

[2] Florian Cajori, *A History of Mathematics* (London: The Macmillan Company, 1931), p. 351.

bility to work with the mathematics teachers toward better high-school preparation of their students. Perhaps the hypothesis of this paper will help to clear up some of the confusion surrounding the question of the mathematical needs of science students. If it is true that "Science students need the same mathematics everyone else needs; only they need more of it," then many of the arguments among mathematicians, scientists, and professional educators become meaningless.

SUBGEOMETRIES OF PROJECTIVE GEOMETRY AS THE THEORIES OF TENSORS

THOMAS L. WADE

1. INTRODUCTION. This paper is concerned with the consideration of a subgeometry of classical (flat) projective geometry as (A) the theory of a tensor in lieu of the customary consideration of such a geometry as (B) the invariant theory of a subgroup of the general linear projective transformation group. So far as is known the viewpoint (A) in regard to flat geometries, and its consequent developments, has appeared in the literature only in the form of a brief and restricted note by the author [1]*, followed by two special applications [2] and [3] of that note. However, the utilization of such a viewpoint toward the new generalized differential geometries has been a basic factor in their development, as indicated in the remarks of Veblen [4]:

> In recent years geometry has passed definitely beyond the boundaries set for it by the Erlanger Programm. According to the Erlanger Programm a geometry is the invariant theory of a group. According to the new conception a geometry is the theory of an invariant (A definition of an invariant, in the sense in which I am using it, will be found in my Cambridge Tract, Invariants of Quadratic Differential Forms, 1927). This invariant may or may not have a non-identical group of automorphisms. If it has such a group, the geometry will be one of the classical type characterized by Klein. If not, it is of a generalized type. Thus the group of a space is regarded as one of its important properties, but not as its all sufficient characteristic one.

As indicated by subsequent remarks in his lecture, by an "invariant" Veblen means a *tensor*, an entity made up of a set of one or more components which obeys a specified law of transformation when a related set of variable coordinates undergo a given transformation. For an introduction to the elements of tensor algebra as used in this paper see [5] and [6].

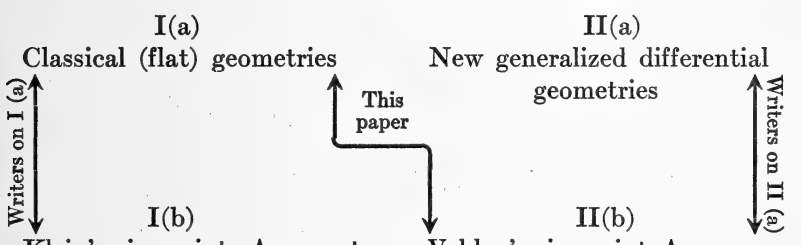
It seems pertinent to quote Veblen and Whitehead [7] from their excellent synopsis on:

> CHANGING VIEWS OF GEOMETRY. The concept of a mathematical science as a body of theorems deduced from axioms seems to have been clearly understood

*Numbers in brackets refer to references at the end of this paper.

by Aristotle if not by earlier Greek scientists. . . . For the Greeks there seems to have been only one space and this was not necessarily a collection of points, but rather a locus in which bodies could be moved about and compared with each other. The fundamental relation between bodies was congruence or superposability. It was after the development of analytic geometry that space came to be regarded as a collection of points. With the advent of the non-Euclidean geometries it became accepted that there are many geometries. But the space was still a locus in which figures were to be compared, the central idea being that of the group of congruent transformations of the space into itself. Thus a geometry came to be regarded as the invariant theory of a transformation group. This point of view was formulated in the Erlanger Programm in 1870 (F. Klein, *Gesammelte Mathematische Abhandlungen*, Berlin, 1921, Vol. 1, p. 460). . . . The transition to the view of geometry as a special case of a mathematical science, the latter being a body of theorems deduced from axioms, was being made at about the beginning of the present century, when a great many different sets of axioms were stated and studied for a variety of geometries by Pasch, Peano, Hilbert, Pieri, E. H. Moore, R. L. Moore, and others. . . . The general concept of a mathematical science did not disturb the Erlanger Programm in any way. For a geometry could be described as a mathematical science which is the theory of a transformation group. But long before the Erlanger Programm had been formulated there were geometries in existence which did not properly fall within its categories, namely the Riemannian geometries. . . . At the present time there are being actively studied, both for physical and mathematical purposes, a large class of spaces which are generalizations of the Riemannian spaces. Like the Riemannian geometries they are, in general, outside the categories of the Erlanger Programm, but they all make use of coordinates, and of differential calculus.

The relation of this paper to the geometries and the viewpoints toward them, as discussed in the preceding paragraphs, may be represented schematically as follows:



Nothing in this paper is intended to minimize the importance of the conventional viewpoint of regarding a classical (flat) geometry

as the invariant theory of a group. As has been aptly stated [8]: "The idea of a transformation group synthesized and generalized all previous concepts of motion and congruence. It also supplied a principle of classification by which it is possible to get a bird's-eye view of the relations between a large number of important geometries . . . ". For excellent treatments of geometry from Klein's viewpoint see [9] and [10]; also [11], [12], [13]. But there are significant advantages, particularly from the invariant viewpoint, of regarding a subgeometry of projective geometry as the theory of a tensor. *Our illustrations here are in 2-space.* The advantages of viewpoint (A) over that of (B) are multiplied many times as the dimension of the space is increased from 2 to 3, 4, . . ., n. In the development of algebraic geometries of 4 and higher dimensions there are a number of indications that the viewpoints (A) and (B) should be regarded as complementary. (For further remarks in this connection see Note 1). In this paper when we speak of an invariant, or more generally, a *concomitant*, we shall refer to a scalar, *a tensor of order zero*; futhermore, the term concomitant will refer to a rational and integral concomitant, unless specifically stated to the contrary.

2. Projective geometry. We use *homogeneous coordinates*, regarding X^1 as the homogeneous coordinates of a point in a flat space of two dimensions, that is, in a plane. So *in this paper a free index is to have the values* 1, 2, 3, *and a repeated index is to be summed for these values.* The structure of a projective 2-space [14] is defined by (preferred) coordinate systems which are related by linear homogeneous transformations of coorinates of the type

$$\left.\begin{aligned} X^1 &= t_1^1 \overline{X}^1 + t_2^1 \overline{X}^2 + t_3^1 \overline{X}^3 \\ X^2 &= t_1^2 \overline{X}^1 + t_2^2 \overline{X}^2 + t_3^2 \overline{X}^3 \\ X^3 &= t_1^3 \overline{X}^1 + t_2^3 \overline{X}^2 + t_3^3 \overline{X}^3 \end{aligned}\right\} \quad \text{or} \quad X^i = t_j^i \overline{X}^j \ , \qquad (1)$$

where the numbers t_j^i are subject only to the condition that $|t| \equiv \det t_j^i \neq 0$. The inverse transformation of (1) is

$$\overline{X}^i = T_j^i X^j \ ,$$

where

$$t_l^i T_k^l = T_l^i t_k^l = \xi_j^i = \begin{cases} 0 \text{ if } i \neq j, \\ 1 \text{ if } i = j. \end{cases}$$

that is, the matrix $[T_j^i]$ is the inverse of $[t_j^i]$. We limit ourselves here to *real projective space* with real transformations. We stipulate the invariancy of the *unviersal concomitant*

$$U_iX^i = U_1X^1 + U_2X^2 + U_3X^3 \quad ,$$

the X^i's being point coordinates, and the U_i's being line coordinates. The equation $U_iX^i = 0$ expresses the incidence of the point X^i and the line U_i .

The fact that we are using homogeneous coordinates instead of non-homogeneous coordinates is significant. For the conventional or *classical tensor algebra uses non-homogenous coordinates, and is concerned with affine tensors, or affinors* [15]. Such a start (with non-homogeneous coordinates) makes it difficult to use tensor algebra in a complete treatment of algebraic invariant theory. But with homogeneous coordinates one can with reasonable ease give a complete discussion of all concomitants associated with any subgeometry of projective geometry. For example, the condition that three lines be copunctual is an affine invariant of those lines (in the sense as that term is used in algebraic invariant theory), since it is a projective invariant. But one needs *projective tensors* to construct this invariant in tensor algebra, and not affinors. Not only can the first fundamental theorem of algebraic invariant theory (which deals with the construction of concomitants), be expressed in tensor algebra, but also the second fundamental theorem (dealing with the reduction of concomitants). (See Note 2.)

From these stipulations and the important results established in the basic paper by Cramlet [16] there follows:

THEOREM 1. FIRST FUNDAMENTAL THEOREM FOR PROJECTIVE CONCOMITANTS. *Every projective concomitant of a set of ground forms in* X^i *and* U_i *(either or both) is expressible by composition as a tensor of order zero with the use of the coefficient tensors of the ground forms and the tensors* e^{ijk}, e_{ijk}, X^i, *and* U_i. We limit our considerations here to forms in which the *coefficient tensors are symmetric in all indices.*

The expression e^{ijk} is the well known *skewsymmetric, relative numerical tensor of weight 1.* This tensor of the third order can be represented explicitly by sectioning it into three *non-tensorial* 2-matrices (the bar over an index indicates its non-tensorial character):

$$\bar{e}^{ij1} = \begin{bmatrix} 0 & 0 & 0 \\ 0 & 0 & 1 \\ 0 & -1 & 0 \end{bmatrix}, \quad \bar{e}^{ij2} = \begin{bmatrix} 0 & 0 & -1 \\ 0 & 0 & 0 \\ 1 & 0 & 0 \end{bmatrix}, \quad \bar{e}^{ij3} = \begin{bmatrix} 0 & 1 & 0 \\ -1 & 0 & 0 \\ 0 & 0 & 0 \end{bmatrix}. \quad (2)$$

The law of transformation of e^{ijk} is

$$\begin{aligned} e^{ijk} &= |t|^{-1}\, t^i_s t^j_t t^k_u \bar{e}^{stu} \quad , \\ \text{or,} \qquad \bar{e}^{stu} &= |t|^{+1}\, T^s_i T^t_j T^u_k e^{ijk} \quad . \end{aligned} \qquad (3)$$

Similarly, e_{ijk} is the *skewsymmetric, relative numerical tensor of weight—1*; and it may in like manner be sectioned into three non-tensorial 2-matrices;

$$\bar{e}_{ij1} = \begin{bmatrix} 0 & 0 & 0 \\ 0 & 0 & 1 \\ 0 & -1 & 0 \end{bmatrix}, \quad \bar{e}_{ij2} = \begin{bmatrix} 0 & 0 & -1 \\ 0 & 0 & 0 \\ 1 & 0 & 0 \end{bmatrix}, \quad \bar{e}_{ij3} = \begin{bmatrix} 0 & 1 & 0 \\ -1 & 0 & 0 \\ 0 & 0 & 0 \end{bmatrix}. \quad (4)$$

The law of transformation of e_{ijk} is

$$\begin{aligned} e_{ijk} &= |t|T^r_i T^s_j T^t_k \bar{e}_{rst} \quad , \\ \text{or} \qquad \bar{e}_{stu} &= |t|^{-1} t^i_s t^j_t t^k_u e_{ijk} \quad . \end{aligned} \qquad (5)$$

The relative numerical tensor e^{ijk} will be referred to as the *projective numerical contravariant tensor*, and e_{ijk} as the *projective numerical covariant tensor.*

Example 1. The lines B_i and C_i with equations $B_iX^i = 0$ and $C_iX^i = 0$ determine the projective contravariant vector (tensor of order one.)

$$D^i = e^{ijk}B_jC_k \quad .$$

D^i is the point of intersection of these lines. Its equation is

$$e^{ijk}B_jC_kU_i = 0 \quad .$$

Example 2. The points B^i and C^i with equations $B^iU_i = 0$ and $C^iU_i = 0$ determine the projective covariant vector

$$D_i = e_{ijk}B^jC^k \quad .$$

D_i is the line of junction of these points. Its equation is

$$e_{ijk}X^iB^jC^k = 0.$$

Example 3. The resultant of the linear forms B_iX^i, C_iX^i, and D_iX^i is

$$B_iC_jD_ke^{ijk} \equiv \begin{vmatrix} B_1 & B_2 & B_3 \\ C_1 & C_2 & C_3 \\ D_1 & D_2 & D_3 \end{vmatrix} .$$

If this projective invariant is zero, the lines $B_iX^i = 0$, $C_iX^i = 0$, and $D_iX^i =$ are concurrent. Since B_i, C_i, and D_i are absolute covariant tensors, and e^{ijk} is a relative contravariant tensor of weight 1, the resultant given above is a relative invariant of weight 1. For, using (3),

$$B_iC_jD_ke^{ijk} = |t|^{-1}\bar{B}_i\bar{C}_j\bar{D}_ke^{ijk} \quad ,$$

or

$$\bar{B}_i\bar{C}_j\bar{D}_ke^{ijk} = |t|\,B_iC_jD_ke^{ijk} \quad .$$

Thus we have a proof (for $n = 3$) of the well known (Bocher) [17]

Theorem. The resultant of a set of n linear forms in n (point) *variables is a relative invariant of weight 1.*

Example 4. The resultant of the linear forms B^iU_i, C^iU_i, and D^iU_i is

$$B^iC^jD^k e_{ijk} \quad .$$

If this projective invariant is zero, the points $B^iU_i = 0$, $C^iU_i = 0$, and $D^iU_i = 0$ are collinear. Similar to the procedure in Example 3, we get, using (5)

$$\bar{B}^i\bar{C}^j\bar{D}^k e_{ijk} = |t|^{-1} B^iC^jD^k e_{ijk} \ ,$$

which shows that the invariant under consideration is of weight -1, since e_{ijk} is of weight -1. In general, *the weight of a projective concomitant of a set of ground forms in* X^i *is equal to the number of factors of the type* e^{ijk} *which appear therein;* and, *the weight of a concomitant of a set of ground forms in* U_i *is equal to the number of factors of the type* e_{ijk} *appearing in the concomitant.*

Example 5. The discriminant D of the conic [18]

$$B_{ij}X^iX^j = 0 \quad ,$$

an invariant of degree three and weight two, is given by

$$6D = B_{ij}B_{kl}B_{mn}e^{ikm}e^{jln} \equiv 6 \begin{vmatrix} B_{11} & B_{12} & B_{13} \\ B_{21} & B_{22} & B_{23} \\ B_{31} & B_{32} & B_{33} \end{vmatrix} \ .$$

The line equation of the conic is

$$B_{ij}B_{kl}e^{ikm}e^{jln}U_mU_n = 0 \quad .$$

The line $C_iX^i = 0$ is tangent to the conic if

$$B_{ij}B_{kl}e^{ikm}e^{jln}C_mC_n = 0 \quad .$$

Example 6. The polar of the point B^i with respect to the conic $C_{ij}X^iX^j = 0$ is

$$C_{ij}X^iB^j = 0 \quad .$$

Example 7. The pole of the line B_i with respect to the conic $C^{ij}U_iU_j = 0$ is

$$C^{ij}B_iU_j = 0 \quad .$$

Example 8. For the ternary cubic $C_{ijk}X^iX^jX^k$ the well known projective invariant S of degree four and weight four is given by

$$S = C_{ilo}C_{mpr}C_{qsj}C_{tkn}e^{ijk}e^{lmn}e^{opq}e^{rst} \quad .$$

Expanded, this invariant has twenty-five terms [19].

Example 9. The equation of the polar conic of the line $B_iX^i = 0$ with respect to the cubic curve $C_{ijk}X^iX^jX^k = 0$ is

$$C_{ijk}C_{lmn}e^{lip}e^{jmq}X^kX^nB_pB_q = 0 \quad . \tag{6}$$

Compare with Clebsch [20] and White [21].

Example 10. The equation of the polar conic of the line $B_iX_i = 0$ with respect to the cubic curve of the third class

$$C^{ijk}U_iU_jU_k = 0$$

is (7)

$$C^{ijk}B_iU_jU_k = 0 \quad .$$

For interesting properties of (7) see Clebsch [22].

Example 11. The equation of the polar conic of the point $B^iU_i = 0$ with respect to the cubic curve of the third order

$$C_{ijk}X^iX^jX^k = 0$$

is (8)

$$C_{ijk}X^iX^jB^k = 0 \quad .$$

Compare with Clebsch [23], and White [24]. The equation of the polar line (or second polar) of the point B^i with respect to the curve of the third order is

$$C_{ijk}B^iB^jX^k = 0 \quad .$$

3. Affine geometry. If in the ternary domain we hold the linear form

$$L_iX^i \quad , \qquad \text{where} \qquad L_i = [\ 0, \quad 0, \quad 1\ ] \quad , \qquad (9)$$

latent, or invariant, we have the special numerical covariant tensor of order one, or covariant vector, L_i. The equation

$$L_iX^i = 0$$

is the equation to the *line at infinity*. The body of definitions and theorems which express properties that are left unchanged under the invariancy of $L_iX^i = 0$ is called *affine geometry*. From the viewpoint of tensor algebra we may state the obvious

Adjunction Principle 1. *Affine geometry as a subgeometry of projective geometry as stated in tensor-invariant terminology is the theory of the covariant numerical tensor*

$$L_i = [\ 0\ ,\ \ 0\ ,\ \ 1\ ] \quad .$$

This principle corresponds to the famous *Adjunction Theorem* of classical invariant theory; this has been stated by Weitzenbock as follows [25]:

Nicht-projective Invarianten. 15. Allgemeines. Das Problem, die invarianten Eigenschaften zu bestimmen, welche irgendwelche geometrische Figuren gegenubereiner Transformations-gruppe besitzen, wurde zuerst von F. Klein in seinem Erlanger Programm formuliert. . . . Geometrische Betrachtungen fuhrten F. Klein insbesondere zu der Frage, wie sich invariante Beziehungen umsetzen, wenn man statt G eine umfassendere Gruppe G. nimmt. Nehmen wir G' als die allgemeine projektive Gruppe Γ und denken uns die lineare Gruppe G. wie angefuhrt, dadurch definiert, dass bei ihr gewisse Formen Φ_i invariant bleiben, so liegt es nahe, zwecks Aufstellung aller Komitanten J_G von Grundformen F bzw. G folgendes Verfahren einzuschlagen ("*Adjunktionssatz*"): Man adjungiert die Φ_i zum Grundformen-system (F_i) und sucht fur das so erweiterte System (F_i, Φ_i) *projective* Invarianten JΓ. Jede JΓ inder die Koeffizienten

wenigstens einer der F_i wirlkich vorkommen, ist dann sicher eine J_G. Das Umgekehrte gilt aber nicht allgemein, wenigstens nicht fur ganze rationale Invariante; inwieweit diese Umkehrung gilt, ist eine noch ungeloste Frage.

In group theory this appears in the theorem [26]: "In every case a sub-group of the general projective group of the plane must leave at rest either a point, a straight line, or a conic". Turnbull has made some interesting remarks on the Adjunction Theorem [27].

Since the product of two tensors is a tensor, we have the additional tensor A^{ij} defined by

$$A^{ij} = e^{ijk}L_k \quad .$$

Since $$L_k = [\,0\,,\ \ 0\,,\ \ 1\,]\ ,$$

we have $$A^{ij} = e^{ij3}\ , \tag{10}$$

or, by (2),

$$A^{ij} = \begin{bmatrix} 0 & 1 & 0 \\ -1 & 0 & 0 \\ 0 & 0 & 0 \end{bmatrix} . \tag{11}$$

It should be noted that *while this matrix is not a tensor under the unrestricted projective transformation, it is a tensor under the restricted transformation which leaves the line at infinity invariant, and thus is an affine tensor.* We shall speak of L_i as the *affine numerical covariant vector*, and of A^{ij} as the *affine numerical contravariant tensor.* These are not affine tensors in the sense of affinors or polyadics, but are affine tensors which arise because of the specializaation of the projective tensor L_i as the basic affine tensor as herein defined.

There follows immediately

THEOREM 11. FIRST FUNDAMENTAL THEOREM FOR AFFINE CONCOMITANTS. *Every affine concomitant for a set of ground forms in* X^1 *and* U_i *is expressible by composition as a tensor of order zero with the use of the coefficient tensors of the ground forms and the tensors*

e^{ijk}, e_{ijk}, L_i, A^{ij}, X^i, *and* U_i. Since $A^{ij} = e^{ijk}L_k$, it is not essential to include A^{ij} in this list of "building stones" of affine geometry, but it seems desirable to do so because of its common occurrence.

Example 12. The line B_i with equation $B_iX^i + 0$ has associated with it the affine contravariant vector

$$C^i = A^{ij}B_i \equiv [\ B_2\ ,\ -B_1\ ,\ 0\ ]\ .$$

This is the point at infinity on $B_iX^i = 0$, and its equation is

$$U_iB_jA^{ij} = 0\ , \qquad \text{or} \qquad B_2U_1 - B_1\ U_2 = 0\ .$$

Example 13. The point B^i with equation $B^iU_i = 0$ has the affine invariant

$$B^iL_i \equiv B^3\ .$$

If this invariant is zero, the point lies on the line at infinity.

Example 14. The lines $B_iX^i = 0$ and $C_iX^i = 0$ have affine invariant

$$B_iC_jA^{ij} \equiv B_1C_2 - B_2C_1\ .$$

If this invariant is zero, the lines are parallel.

Example 15. The conic $B_{ij}X^iX^j = 0$ is a parabola (see Note 3) if the invariant

$$B_{ij}B_{kl}A^{ik}A^{jl} = 2\ (B_{11}\ B_{22} - B_{12}\ B_{12})$$

is zero.

Example 16. The equation of the center of the conic $B_{ij}X^iX^j = 0$ is

$$B_{ij}B_{kl}e^{ikm}A^{jl}U_m = 0\ .$$

This result follows immediately from the line equation of the conic given in Example 5, considering the center as the pole of the line at infinity, and using (10).

Example 17. The equation of the center of the conic $B^{ij}U_iU_j = 0$ is

$$B^{ij}L_iU_j = 0 \quad .$$

Example 18. The equation of the product of the two asymptotes of $B_{ij}X^iX^j = 0$ is

$$3\,(B_{ij}B_{kl}A^{ik}A^{jl})\,(B_{mn}X^mX^n) - (B_{ij}B_{kl}B_{mn}e^{ikm}e^{jln})\,(L_sX^s)^2 = 0 \quad .$$

Example 19. If in equation (6) of Example 9 we replace B_p by L_p and make use of (10), we have immediately that the equation of the polar conic of the line at infinity with respect to the cubic curve $C_{ijk}X^iX^jX^k = 0$ is

$$C_{ijk}C_{lmn}A^{il}A^{jm}X^kX^m = 0. \tag{12}$$

For the interesting relation of this conic with respect to the asymptotic triangle of the cubic curve see Salmon [28].

Example 20. If in (7) of Example 10 we replace B_i by L_i, we have that the equation of the polar conic of the line at infinity with respect to the cubic curve $C^{ijk}U_iU_jU_k = 0$ is

$$C^{ijk}L_iU_jU_k = 0.$$

Example 21. The cubic curve of the third order $C_{ijk}X^iX^jX^k = 0$ has the affine invariants (also affine invariants of the conic (12))

$$I_1 = C_{ijk}C_{lmn}C_{pqr}C_{stu}A^{il}A^{jm}A^{ps}A^{qt}A^{kr}A^{nu} \quad ,$$

and

$$I_2 = C_{iln}C_{jmp}C_{koq}e^{ijk}A^{lm}A^{no}A^{pq} \equiv 6 \begin{vmatrix} C_{111} & C_{112} & C_{113} \\ C_{211} & C_{221} & C_{231} \\ C_{221} & C_{222} & C_{223} \end{vmatrix} \quad .$$

It seems that these invariants were first found and studied by Thomae [29]. He established the interesting fact that if $I_2 = 0$, the asymptotes of the cubic curve of the third order are concurrent.

If $I_1 = 0$ and $I_2 = 0$, the cubic curve of the third order has a double point at infinity. Such cubics have been studied in considerable detail by Greiner [30].

4. Euclidean (parabolic) metric geometry. In the affine plane geometry let the degenerate line conic

$$(U_1)^2 + (U_2)^2 = 0 \quad \text{or} \quad E^{ij}U_iU_j = 0 \quad , \tag{13}$$

where

$$E^{ij} = \begin{bmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 0 \end{bmatrix} , \tag{14}$$

be invariant. We now have the additional numerical tensor E^{ij}; it will be called the *euclidean numerical contravariant tensor.* The equation (13) is the equation to the *circular points at infinity.* The body of definitions and theorems which express properties that are left unchanged under the invariancy of (13) is called *euclidean (parabolic) metric geometry.* From the viewpoint of tensor algebra there follows immediately

Adjunction Principle II. *Euclidean (parabolic) metric geometry as a subgeometry of affine geometry is the theory of the contravariant numerical tensor*

$$E^{ij} = \begin{bmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 0 \end{bmatrix} .$$

It is a common procedure in tensor algebra to take the inverse of a given matrix which is a tensor and thereby obtain another useful tensor. Since $|E^{ij}| = 0$, the inverse of E^{ij} does not exist. But the adjoint of E^{ij} is a tensor, and is given by

$$E_{ij} = \tfrac{1}{2}e_{irs}e_{jmn}E^{rm}E^{sn} \equiv \begin{bmatrix} 0 & 0 & 0 \\ 0 & 0 & 0 \\ 0 & 0 & 1 \end{bmatrix} . \tag{15}$$

We shall call this the *euclidean numerical covariant tensor.* One might say that anything that can be done with E_{ij} in tensor algebra, can also be done with L_i; but more about this later.

We now state the evident

THEOREM III. FIRST FUNDAMENTAL THEOREM FOR EUCLIDEAN CONCOMITANTS. *Every euclidean concomitant for a set of ground forms in* X^1 *and* U_i *is expressible by composition as a tensor of order zero with the use of the coefficient tensors of the ground forms and the tensors* e^{ijk}, e_{ijk}, L_i, A^{ij}, E^{ij}, E_{ij}, X^i, *and* U_i.

Example 22. The line $B_iX^i = 0$ has the euclidean invariant

$$B_iB_jE^{ij} \equiv (B_1)^2 + (B_2)^2 \quad .$$

The line B_i has associated with it the euclidean contravariant vector.

$$C^i = E^{ij}B_j \equiv [\, B_1, \quad B_2, \quad 0\,] \; .$$

This is the point at infinity in the direction perpendicular to B_i, and its equation is

$$E^{ij}U_iB_j = 0, \qquad \text{or} \qquad B_1U_1 + B_2U_2 = 0.$$

Example 23. The conic $B_{ij}X^iX^j = 0$ has the euclidean invariant

$$B_{ij}E^{ij} \equiv B_{11} + B_{22} \quad .$$

An *irreducible complete system* of euclidean concomitants for the conic above was established by Weitzenbock [31] using the symbolic notation. The invariants of this system have been given in tensor form by the writer [2]. This irreducible complete system consists of eighteen concomitants. Of these concomitants only nine are algebraically independent; so the eighteen members of the irreducible complete system are connected by nine functionally independent syzygies. Such a system or *set of syzygies* was found by the writer [32], and with them an *algebraically complete system* of concomitants for the conic, consisting of course of nine members of the irreducible complete system.

Example 24. The line $B_iX^i = 0$ and the conic $C_{ij}X^iX^j = 0$ have the simultaneous euclidean invariants

$$C_{ij}E^{ik}E^{jm}B_kB_m \quad , \qquad e^{ijk}B_kC_{jl}C_{jm}e^{lms}B_s \quad ,$$

$$e^{ijk}B_kC_{jl}C_{jm}A^{lm} \quad , \qquad A^{ij}B_iC_{jl}E^{lm}B_m \quad .$$

These four simultaneous invariants, with the three of the conic, and the one of the line, make up an irreducible complete system of euclidean invariants for the line and the conic. However, only six of these invariants are algebraically independent; so the eight irreducible invariants are connected by two functionally independent syzygies.

Example 25. The cubic curve

$$C_{ijk}X^iX^jX^k = 0 \tag{16}$$

has the important euclidean (point) concomitant

$$C_{ijk}C_{lmn}A^{il}e^{jmr}E^{kn}U_r = 0 \quad . \tag{17}$$

It seems that this point was first found by Thomae [29]. He called it the "Kreispol". Using (8) of Example 11 it follows that the polar conic of the pont (17) with respect to the cubic (16) is

$$C_{ijk}C_{lmn}C_{opr}A^{il}e^{jmr}E^{kn}X^oX^p = 0 \quad . \tag{18}$$

Thomae showed that this conic is a circle; hence the name "Kreispol". As a consequence of this theorem and a number of other theorems concerned with the numbers of types of various concomitants, the writer has proved the theorem [33]; "For the cubic curve of the third order every covariant conic whose coefficients are of the third degree in the coefficients of the ground form is a circle".

Example 26. The cubic curve (16) has the interesting euclidean line concomitant

$$C_{ijk}E^{ij}X^k = 0 \quad . \tag{19}$$

Thomae named this the *orthic line* of the cubic curve (16); further, he called cubic curves for which the concomitant (19) vanishes identically *orthic cubics.*; Orthic cubics were also studied by Brooks [34]. The line (19) has the euclidean invariant (and of course this is an euclidean invariant of the cubic (16))

$$I_3 = C_{ijk}C_{lmn}E^{il}E^{jm}E^{kn} \quad ,$$

or

$$I_3 = (C_{111} + C_{122})^2 + (C_{112} + C_{222})^2 \quad .$$

If $I_3 = 0$, the orthic line is a minimal line.

The concomitant (12) of Example 19, the concomitant (19) of this Example, the invariants I_1 , I_2 of Example 21, and the invariant I_3 of this Example were used by Burington and Holt [35], and also by Burington [36], in their studies of the cubic curve of the third order. It seems that in the papers [35] and [36] the concomitants mentioned above were obtained independently of Thomae's results, using the Lie theory of continuous groups as applied to invariants (partial differential equations) developed by MacDuffee [37] and Dickson [38].

Example 27. The cubic curve (16) has the additional euclidean invariants

$$I_4 = C_{ijk}C_{lmn}A^{il}A^{jm}E^{kn} \quad ,$$

or

$$I_4 = 2\,[C_{111}C_{122} - (C_{112})^2 - (C_{122})^2 + C_{112}C_{222}] \quad ;$$

and

$$I_5 = C_{i_1j_1k_1}C_{l_1m_1n_1}A^{i_1l_1}e^{j_1m_1r_1}E^{k_1n_1}$$

$$\cdot\, C_{l_2j_2k_2}C_{l_2m_2n_2}A^{i_2l_2}e^{j_2m_2r_2}E^{k_2n_2}$$

$$\cdot\, C_{l_3j_3k_3}C_{l_3m_3n_3}A^{i_3l_3}e^{j_3m_3n_3}E^{k_3n_3}C_{r_1r_2r_3} \quad .$$

From (17) we see that if $I_4 = 0$, the "Kreispol" is on the line at infinity. Also from (17) we see that if $I_5 = 0$, the "Kreispol" is on the cubic curve.

With I_3 and I_4 we can construct the invariant

$$\tfrac{1}{2}\, I_4 + I_3 = (C_{111})^2 + 3C_{111}C_{122} + 3C_{112}C_{222} + (C_{222})^2 \quad .$$

If this invariant is zero, the asymptotic triangle of the cubic curve is a right triangle.

Similarly, we can construct the invariant

$$I_3 - 4I_4 = (C_{111} - 3C_{122})^2 + (C_{222} - 3C_{112})^2 \quad .$$

If this invariant is zero, the cubic is a *circular cubic*, that is, goes through the circular points at infinity. Circular cubics were studied by Dolle [39].

As Thomae [29] so ably points out, the invariants of the ternary cubic we have referred to as I_1, I_2, I_3, I_4, I_5, with the two projective invariants, S of Example 8 and T (which for the general cubic contains 103 terms [40], constitute an *algebraically complete system of euclidean invariants for the cubic curve of the third order*. Thomae referred to the invariant of the seventh degree, I_5, as the "Mittelpunktsinvariante".

Up to the present time *an irreducible complete system of euclidean concomitants for the general cubic curve of the third order* has not yet been found. Weitzenbock [41] made a contribution toward this objective in regard to one type of invariants. Further results toward obtaining such an irreducible complete system were obtained by the writer [33].

THE EUCLIDEAN COVARIANT DISTANCE TENSOR. It is useful to give particular attention to the tensor $E_{ij,kl}$ defined by

$$E_{ij,kl} = e_{ijr}E^{rs}e_{skl} \quad . \tag{20}$$

In virtue of the values of the components of E^{rs} as given by (14), the relation (20) may be written

$$E_{ij,kl} = e_{ij1}E^{11}e_{kl1} + e_{ij2}E^{22}e_{kl2} \quad ,$$

or

$$E_{ij,kl} = e_{ij1}e_{kl1} + e_{ij2}e_{kl2} \quad . \tag{21}$$

Recalling that e_{ijk} is skewsymmetric in all indices, we see that $E_{ij,kl}$ has the properties

$$E_{ij,kl} = -E_{ji,kl} = -E_{ij,lk} \quad ; \tag{22}$$

that is, $E_{ij,kl}$ is skewsymmetric in i and j, and also in k and l. Further, $E_{ij,kl}$ is symmetric for the double interchange of i and j, and k and l; that is,

$$E_{ij,kl} = E_{ji,lk} \quad . \tag{23}$$

Also

$$E_{ij,kl} = E_{kl,ij} \quad . \tag{24}$$

Now a basic identity satisfied by e_{ijk} is [42]

$$e_{ijk}e_{lmn} = e_{ijk}e_{lmn} + e_{lik}e_{jmn} + e_{ijl}e_{kmn} \quad . \tag{25}$$

A special case of this is

$$e_{ij1}e_{kl1} = e_{kj1} + e_{li1} + e_{ik1}e_{jl1} \quad ; \tag{26}$$

and similarly

$$e_{ij2}e_{kl2} = e_{kj2}e_{li2} + e_{lk2}e_{ji2} \quad . \tag{27}$$

From (21), (26), and (27) it follows that

$$E_{ij,kl} = E_{kj,il} + E_{ik,jl} \quad . \tag{28}$$

It is of interest to note the similarity of the properties of $E_{ij,kl}$ as given by (22), (23), (24), and (28) with like properties of the covariant Riemann-Christoffel curvature tensor $R_{ij,kl}$ [43], [44], and [45]. We shall speak of $E_{ij,kl}$ as the *euclidean covariant distance tensor.*

Example 28. Two points B^i and C^i have the euclidean metric invariants

$$I = B^iC^jE_{ij,kl}B^kC^l \quad , \tag{29}$$

or

$$I = (B^1C^3 - B^3C^1)^2 + (B^2C^3 - B^3C^2)^2 \quad ;$$

and

$$\begin{aligned} I_2 &= B^iB^jE_{ij} \quad , \quad \text{or} \quad I_2 = (B^3)^2 \quad , \\ I_3 &= C^iC^jE_{ij} \quad , \quad \text{or} \quad I_3 = (C^3)^2 \quad . \end{aligned} \tag{30}$$

Note that a point B^i has an affine invariant $B^iL_i = B^3$, but the euclidean metric invariant of the point is $(B^3)^2 = B^iB^jE_{ij}$.

Using the above invariants we can construct the absolute euclidean metric invariant of the points B^i and C^i ,

$$\frac{B^iC^jE_{ij,kl}B^kC^l}{(B^iB^jE_{ij})\ (C^kC^lE_{kl})} \tag{31}$$

or

$$\frac{(B^1C^3 - B^3C^1)^2 + (B^2C^3 - B^3C^2)^2}{(B^3)^2\ (C^3)^2} \ . \tag{32}$$

The expression (31), or (32), is the square of the distance in homogeneous coordinates between the points B^i and C^i [46], [47].

Example 29. The three points B^i, C^i, D^i have the absolute euclidean metric invariant

$$\frac{\frac{1}{4}\ (B^iC^jD^k\ e_{ijk})^2}{(B^iB^jE_{ij})\ (C^kC^lE_{kl})\ (D^mD^nE_{mn})} \ . \tag{33}$$

This is the square of the area of the triangle with the three given points as vertices.

Example 30. The irreducible complete system of euclidean invariants for the three lines

$$B_iX^i = 0 \ , \qquad C_iX^i = 0 \ , \qquad D_iX^i = 0 \tag{34}$$

is made up of the ten invariants

$$B_iB_jE^{ij} \ , \qquad C_iC_jE^{ij} \ , \qquad D_iD_jE^{ij} \ ,$$

$$C_iD_jA^{ij} \ , \qquad D_iB_jA^{ij} \ , \qquad B_iC_jA^{ij} \ ,$$

$$C_iD_jE^{ij} \ , \qquad D_iB_jE^{ij} \ , \qquad B_iC_jE^{ij} \ ,$$

$$B_iC_jD_ke^{ijk} \ .$$

Only six of these irreducible invariants are algebraically independent. So the above ten invariants are connected by four functionally independent syzygies [3].

Since the above ten invariants constitute an irreducible complete system of invariants for the three line configuration (triangle) (34), it follows that all invariants of this triangle are expressible in terms of these invariants, and all polynomial invariants are expressible rationally and integrally in terms of them.

Example 31. The irreducible complete system (identical with the algebraically complete system in this case) of euclidean metric invariants for the conic

$$B^{ij}U_iU_j = 0 \tag{35}$$

consists of the three invariants

$$B^{ij}E_{ij} \quad , \quad B^{ik}E_{ij,kl}B^{jl} \quad ,$$

$$B^{ij}B^{kl}B^{mn}e_{ikm}e_{jln} \quad .$$

The equation of the director circle of (35) is

$$B^{ik}E_{ij,kl}X^jX^l = 0 \quad .$$

It might be of interest to compare these expressions with those given by Weitzenbock [48], the latter being an interesting paper which makes use of the symbolic method in a study of the euclidean concomitants of the conic (35).

Example 32. Among the euclidean concomitants of the cubic of the third class

$$C^{ijk}U_iU_jU_k = 0$$

are the point

$$C^{ijk}L_iL_jU_k = 0 \quad ,$$

the conic

$$C^{ijk}L_iU_jU_k = 0 \quad ,$$

and the invariants

$$C^{ijk}L_iL_jL_k \quad \text{and} \quad C^{ikr}E_{ij,kl}C^{jls}E_{rs} \quad .$$

So far as in known there has been no invariant study of the cubic of the third class analogous to that of the cubic of the third order made by Thomae [29], and his students Greiner [30] and Dolle [39].

5. Elliptic metric geometry. In the projective plane let the conic

$$(U_1)^2 + (U_2)^2 + (U_3)^2 = 0 \ , \quad \text{or} \quad \xi^{ij}U_iU_j = 0 \ , \quad (36)$$

where

$$\xi^{ij} = \begin{bmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{bmatrix} , \qquad (37)$$

be invariant. We now have the additional numerical tensor ξ^{ij}; it will be called the *elliptic numerical contravariant tensor.* The body of definitions and theorems which express properties that are left unchanged under the invariancy of (36) is called *elliptic metric geometry.* From the viewpoint of tensor algebra this may be expressed in

Adjunction Principle III. *Elliptic metric geometry as a subgeometry of projective geometry is the theory of the contravariant numerical tensor*

$$\xi^{ij} = \begin{bmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{bmatrix} .$$

Also we have associated with ξ^{ij} the elliptic *covariant numerical tensor* ξ_{ij} (the inverse of ξ^{ij}) given by

$$\xi_{ij} = \tfrac{1}{2}\, e_{irs}e_{jmn}\ \xi^{rm}\ \xi^{sn} \equiv \begin{bmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{bmatrix} .$$

Thence,

THEOREM IV. FIRST FUNDAMENTAL THEOREM FOR ELLIPTIC CONCOMITANTS. *Every elliptic concomitant for a set of ground forms in* X^i *and* U_i *is expressible by composition as a tensor of order zero with the use of the coefficient tensors of the ground forms and the tensors* e^{ijk}, e_{ijk}, ξ^{ij}, ξ_{ij}, X^i, *and* U_i.

Example 33. The line B_i with equation $B_iX^i = 0$ has the elliptic invariant

$$B_iB_j \ \xi^{ij} \equiv (B_1)^2 + (B_2)^2 + (B_3)^2 \quad .$$

Example 34. The lines B_i and C_i have the elliptic invariant

$$B_iC_j \ \xi^{ij} \equiv B_1C_1 + B_2C_2 + B_3C_3 \quad .$$

Example 35. The line B_i has the absolute pole

$$B^i = \xi^{ij}B_i \text{ whose equation is } \xi^{ij}B_iU_j = 0 \ .$$

Example 36. The point C^i with equation $C^iU_i = 0$ has the absolute polar

$$C_j = \xi_{ij}C^i \text{ whose equation is } \xi_{ij}C^iX^j = 0 \quad .$$

THE ELLIPTIC TENSORS $\xi_{ij,kl}$ AND $\xi^{ij,kl}$. Corresponding to the euclidean covariant distance tensor $E_{ij,kl}$ we have in elliptic geometry the tensor $\xi_{ij,kl}$ defined by

$$\xi_{ij,kl} = e_{ijr} \ \xi^{rs} \ e_{skl} \quad , \tag{38}$$

and also the tensor $\xi^{ij,kl}$ defined by

$$\xi^{ij,kl} = e^{ijr} \ \xi_{rs}e^{skl} \quad . \tag{39}$$

In euclidean metric geometry the tensor which is the analogue of $\xi^{ij,kl}$ is

$$E^{ij,kl} = e^{ijr}E_{rs}e^{skl} \quad ,$$

or, in virtue of the values of E_{rs} given by (15),

$$E^{ij,kl} = (e^{ij3}) \ (e^{3kl})$$

or by (10)
$$E^{ij,kl} = (A^{ij}) \ (A^{kl}) \tag{40}$$

Thus, *viewing the metric subgeometries of projective geometry as the theories of tensors gives additional insight into the differences between the dualistic* [49] *metric elliptic geometry and the non-dualistic metric euclidean geometry.* For, *from the viewpoint of tensor algebra, one may say that the reason for the existence of many of the degeneracies and simplifications of euclidean geometry relative to the elliptic and hyperbolic metric geometries is due to the simplicity of* E_{ij}, *and the consequent relationship* (40).

Example 37. The conic $B_{ij}X^iX^j = 0$ has the elliptic invariants

$$B_{ij}\ \xi^{ij}, \qquad \text{or} \qquad B_{11} + B_{22} + B_{33}\ ;$$

$$B_{ik}B_{jl}\ \xi^{il}\ \xi^{jk}, \qquad \text{or} \qquad (B_{11})^2 + (B_{22})^2 + (B_{33})^2 + 2(B_{12})^2 + 2(B_{13})^2 + 2(B_{23})^2\ ;$$

$$B_{ij}B_{kl}B_{mn}e^{ikm}e^{jln}, \text{ or } 6 \begin{vmatrix} B_{11} & B_{12} & B_{13} \\ B_{21} & B_{22} & B_{23} \\ B_3 & B_{32} & B_{33} \end{vmatrix} .$$

These invariants form an *algebraically complete system of elliptic invariants for the conic,* and with the use of certain tensor identities it can be shown that *they constitute also an irreducible complete system of such invariants.* Just as the system of euclidean invariants of a conic are used as an aid in classifying conics in euclidean geometry, these elliptic invariants may be used as an aid in classifying conics in elliptic geometry. See Klein [50].

Example 38. The two points B^i and C^i have the elliptic invariants

$$B^iB^j\ \xi_{ij}\ , \qquad C^iC^j\ \xi_{ij}\ , \qquad B^iC^j\ \xi_{ij}\ ,$$

and

$$B^iC^j\ \xi_{ij,kl}B^kC^l\ .$$

The latter of these expanded is

$$(B^1C^2 - B^2C^1)^2 + (B\,C^3 - B^3C)^2 + B^2C^3 - B^3C^2)^2\ .$$

With these polynomial invariants we can construct the absolute invariants

$$\frac{(B^iC^j\ \xi^{ij})^2}{(B^iB^j\ \xi_{ij})\ (C^kC^l\ \xi_{kl})} \quad \text{and} \quad \frac{B^iC^j\ \xi_{ij,kl}B^kC^l}{(B^iB^j\ \xi_{ij})\ (C^kC^l\ \xi_{kl})}$$

These two absolute elliptic invariants are basic in the concept of distance in elliptic metric geometry [51], [52], [53], [54], [55].

Example 39. Dually to Example 38 the two lines B_i and C_i have the elliptic invariants [51], [52]

$$B_iB_j\ \xi^{ij} \quad , \quad C_iC_j\ \xi^{ij},$$

$$B_iC_j\ \xi^{ij} \quad , \quad B_iC_j\ \xi^{ij,kl}B_kC_l \quad .$$

Example 40. The three points B^i, C^i, D^i have the absolute elliptic invariant (compare with Example 29)

$$\frac{(B^iC^jD^ke_{ijk})^2}{(B^iB^j\ \xi_{ij})\ (C^kC^l\ \xi_{kl})\ (D^mD^n\ \xi_{ij})} \quad .$$

The positive square root of this invariant is called by Coolidge [56] the "sine amplitude" of the triangle with vertices B^i, C^i, D^i.

6. Hyperbolic metric geometry. A sketch of hyperbolic metric geometry as the theory of a tensor paralleling that of elliptic metric geometry as given in section 5 is easily presented. In the projective plane we let the conic

$$(U_1)^2 + (U_2)^2 - (U_3)^2 = 0, \quad \text{or} \quad H^{ij}U_iU_j = 0 \quad , \quad (41)$$

where

$$H^{ij} = \begin{bmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & -1 \end{bmatrix} , \quad (42)$$

be invariant. We now have the additional numerical tensor H^{ij}; it will be called the *hyperbolic numerical contravariant tensor.* The body of definitions and theorems which express properties that are left unchanged under the invariancy of (41) is called *hyperbolic metric geometry.* We may state

ADJUNCTION PRINCIPLE IV. *Hyperbolic metric geometry as a subgeometry of projective geometry is the theory of the contravariant numerical tensor*

$$H^{ij} = \begin{bmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & -1 \end{bmatrix}.$$

We have associated with H^{ij} the *hyperbolic covariant numerical tensor* H_{ij} given by

$$H_{ij} = \tfrac{1}{2}\, e_{irs}e_{jmn}H^{rm}H^{sn} \equiv \begin{bmatrix} 1 & 0 & 0 \\ 0 & -1 & 0 \\ 0 & 0 & -1 \end{bmatrix}.$$

There follows

THEOREM V. FIRST FUNDAMENTAL THEOREM FOR HYPERBOLIC CONCOMITANTS. *Every hyperbolic concomitant for a set of ground forms in* X^i *and* U_i *is expressible by composition as a tensor of order zero with the use of the coefficient tensors of the ground forms and the tensors* e^{ijk}, e_{ijk}, H^{ij}, H_{ij}, X^i, *and* U_i.

Examples could readily be given, but they would be closely analogous to those of section 5. One of particular interest is

Example 40. The points B^i and C^i_j have associated with them the hyperbolic concomitant curve of the second order

$$(e_{ijk}B^iC^jX^k)^2 - 4\,(H_{ij}B^iC^j)\,(H_{kl}B^kX^l)\,(H_{mn}C^mX^n) = 0.$$

Some properties of this curve were given by Study [57].

Notes

Note 1. The method presented in this paper of constructing algebraic concomitants with the use of tensor algebra is a very elementary procedure from the viewpoint of general tensor theory, but is of considerable interest and importance from the algebraic invariant viewpoint, since it does away with the necessity of following one of the commonly used procedures:

(i) *The elimination of the transformation parameters.* This is the method given in the typical analytic geometry book.

(ii) *The solution of the partial differential equations which define a group.* See MacDuffee [37], Burington and Holt [35], and Paradise, American Math. Monthly, Vol. 33, 1926, pp. 406-418.

(iii) *The use of the symbolic invariant notation of Aronhold and Clebsch* which was extended by Weitzenbock in his book *Invariantentheorie* to higher dimensions through the use of "Komplex-Symbolik", and to restricted transformations through the use of additional symbolic factors.

A study of these methods discloses the following things:

Method (i) works fairly well for the line and the conic in 2-space under euclidean transformations. But it becomes quite difficult, if not humanly impossible, to apply to higher forms in 2-space (for example, to obtain the invariants in Example 21 and 27), and to forms in higher space.

Method (ii) is difficult to carry over to other geometries and to higher spaces.

Method (iii) deals with "ideal vectors", and has never been popular in America, due partly no doubt to the fact that the algebra of "ideal vectors" is exceedingly specialized, being of little use in anything other than invariant theory.

All of these methods have contributed much to invariant theory, and without their contributions undoubtedly the method presented

in this paper would not have been developed, for invariants were discovered using method (i). The contributions of method (ii) are great, and the theory of continuous groups will, it seems, continue to supply the criterion as to the number of algebraically independent concomitants of a given type in a geometry. But it appears easier to construct concomitants with tensors, rather than solve differential equations to get them. And the contributions of method (iii) form the major part of invariant theory developed during the past ninety years.

As to the method of tensor algebra, it does away with the arduous labor of eliminating the transformation parameter, or of solving differential equations. Further, the geometric interpretations of many concomitants are obvious when these concomitants are in tensor form, while such geometric interpretations are often diffcult to obtain when these concomitants are written out in detailed scalar algebra, as concomitants are written when they are obtained by solving differential equations. In regard to the symbolic notation, concomitants are as readily obtained and studied in tensor algebra as in the former medium. *So while tensor algebra seems to be a natural tool for the study of algebraic invariants, particular those in connection with latent forms, at the same time such use of tensor algebra serves as an introduction to this apparent universal algebra of substitutional analysis, the use of which is becoming more common in differential geometry, theoretical physics, topology, and multivariate statistical analysis.*

NOTE 2. A statement indicating the importance of the symbolic notation is that of L. E. Dickson in his monograph, ALGEBRAIC INVARIANTS, Wiley and Sons, 1914, p. vi, "This (symbolic) notation must be mastered by those who would go deeply into the theory of invariants and their applications". Further, J. H. Grace and A. Young in their book, The Algebra of Invariants, Cambridge University Press, 1902, p. 368, say, ". . . the wonderful feature of the algebra (symbolic method) is its capacity for reduction." In [2] the writer has established reduction formulas, which are tensor identities, for projective, affine, and euclidean concomitants in 2-space, thus showing that the problem of reduction can also be dealt with in tensor algebra.

NOTE 3. It is necessary to be brief in the examples. In any remark as to the geometric interpretation of the vanishing of an invariant it is assumed that no other invariant of the form or forms under consideration vanishes at the same time. To illustrate, the statement of Example 15 is subject to criticism if the discriminant of the conic is also zero. Also, in an example like 18 it is assumed that the conic is not specialized by the vanishing of any concomitant.

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PHYSICAL SCIENCE KNOWLEDGE OF STUDENTS ENTERING THE PHYSICAL SCIENCE INTEGRATED COURSE AT FLORIDA STATE UNIVERSITY

RICHARD H. JORDAN

The study reported in this paper was conducted in the Fall and Winter quarters of 1949 at Florida State University to determine something of the science background of students entering the integrated physical science course. This information was sought as the basis for the development of an adequate curriculum in the physical science integrated course but it is equally applicable to the curricula of the traditional disciplines. It was hoped that several courses might be developed for the non-science major on the basis of the student's high school training, each of which would satisfy the general education requirements of Florida State University and each of which would be better adapted to the students' varied backgrounds than the one integrated course presently offered to all.

The project was divided into three parts; a pre-test given on the first day of the physical science course to all physical science students; the same test given as a post-test on the last day of the course to the same students; and finally, the same test given to these same students during the latter part of their senior year. In this manner a comparison of the knowledge of the students with and without high school physics and chemistry could be made before they had taken college science, their gain in the physical science course measured and their loss between the course and graduation recorded. This report deals with the first part of the project.

To carry out the evaluation an hour-long, multiple-choice, objective examination was developed. The examination questions were almost wholly simple recall types concerned with factual information; the student's ability to apply the facts was not considered of primary interest at this stage of the investigation. The questions were general in nature, touching upon the fields of astronomy, physics, geology, chemistry, and meteorology. They were selected because of their basic nature or because they tested the student's knowledge of phenomena encountered in his daily living. Questions of a technical or "impractical" nature were omitted.

The items appear quite elementary but past experience with similar tests showed that questions of a somewhat more difficult nature gave almost no spread of scores. Many of the questions characteristic of standard high school chemistry and physics examinations, such as the New York State Regents examinations, were missed by a majority of the students regardless of their high school science training.

An item count was run to give the percent of students who selected each correct and incorrect response. These figures were broken down further on the basis of the student's high school science training, that is, whether he had taken physics, chemistry, physics and chemistry, or neither of these two subjects. Of the 372 participating students, 33 had taken physics, 97 chemistry, 42 both physics and chemistry, and 200 neither physics nor chemistry.

No brief is held for the complete validity of the results. The examination cannot be considered broadly comprehensive and the limitations of objective examinations are recognized. However, the students were given ample time for its completion and they seemed to take the examination seriously. A check through the results tends to substantiate this view. The students did not omit more questions at the end than at the beginning; the general comparison between the groups is quite uniform throughout the examination; certain seemingly easy questions which were missed by many students apparently through casual work are followed by others of equal simplicity answered by most of the students, thus tending to invalidate the theory of a casual attitude. It is believed that the results are sufficiently accurate to indicate a general situation.

These results are not encouraging. It is quite apparent that the average Florida high school graduate who has taken high school physics and chemistry has so little advantage over his fellows in most fields of science, and even in physics and chemistry, that placing him in a special physical science course on this basis is not warranted.[1] The author is reluctant to admit this situation as he hoped genuinely that the student's high school training could be used as a basis to broaden his college general education in science.

The results also indicate that the student graduating from high school knows very little fundamental science, science that might be considered rudimentary to a liberal education. His knowledge of physics and

[1] A high percentage of the participating students were from Florida high schools.

chemistry, even if he has taken these subjects, seems quite limited, and he knows almost nothing about astronomy, daily weather changes, or geology. If he does not go on to college his science education can hardly approach a liberal training.

The results are in some respects expected and in others surprising. The student with high school physics does not seem to be far ahead of his fellows in a knowledge of physics and is almost on a par with the others in an understanding of the other fields of science work. For example, 13 of the 20 questions about physics were missed by 55% or more of those who had taken physics, 14 by 55% or more of those who had taken chemistry, 11 by 55% or more with both physics and chemistry, and 17 by 55% or more who had taken neither. The results on questions in chemistry were equally discouraging. Six of the 11 chemistry questions were missed by more than 50% of those who had taken chemistry, an equal number (and the same questions) by more than 50% of those who had taken physics, 8 by those who had taken both of these subjects and 9 by those who had taken neither.

The students' knowledge of outstanding men of science is extremely limited. Only 18% of those having had physics recognize J. R. Oppenheimer as a physicist. More than 84% of those in any of the 4 categories were unable to place Arthur H. Compton or Harlow Shapley in their respective fields of endeavor. Less than 30% of those in any category associated Copernicus with his heliocentric theory. More than 60% of the students in any one group missed each question about scientists.

The students who had taken both physics and chemistry selected the greatest number of correct answers, those with physics ranked second, followed by those with chemistry. However, the results of no group were encouraging. Of the 50 questions, 31 were missed by more than 50% of the physics group, 36 by more than 50% of the chemistry group, 34 by more than 50% of the physics-chemistry group and 37 by 50% or more of those who had no advanced high school science.

As might be expected all of the students were unfamiliar with most of the questions in astronomy, geology and meteorology.

Answers to certain specific questions were quite astonishing. Of the students, 35% selected "the revolution of the earth around the sun" as the major cause of day and night as we experience it. The physics and chemistry groups were not superior to the others on the questions. One would believe that an understanding of the reason for day and

night would be one of the most fundamental, elementary, and widely known concepts in science. From the class experiences of the physical science staff, it is believed that those statistics are quite valid.

A higher percentage, 75%, recognize that light travels faster than sound. But, on the other side of the balance, almost everyone, including 78% of those who had taken physics, chose green as the color of a pure blue carpet as seen in pure yellow light. The other choices were blue, yellow, black and red. None of the physics students chose black.

Of those having had physics, 22%, and of those having had chemistry, 41% answered incorrectly the temperature at which water freezes on the Centigrade scale, the choices being 100, 0, 32, and -32. That sound cannot travel through a vacuum seems to be quite well-known to most of the students.

Chemistry students seem better grounded than physics students on an understanding of fundamental particles. As these questions were included in the physics work it may explain why the chemistry did almost as well as the physics students on the physics questions. As an example, 51% of the physics students against 36% of those having had chemistry believe an atom is a smaller particle than a proton. Of the physics students, 24%, and of the chemistry students, 35% correctly chose proton.

To the problem, "You burn a 100 watt lamp 40 hours. At 10 cents a kilowatt hour the cost is, 40 cents, 4 dollars, 4 cents, 400 dollars, 40 dollars", 42% of the physics students chose the correct response. In the other groups the percentages ran 37% chemistry, 45% physics and chemistry, 26% neither science. Surprisingly enough 15% of the physics group selected $4.00 and 15%, 4 cents. There was evidently more guess work than arithmetic done on this problem.

Concerning the age of the earth, students of all groups were quite equally distributed between three choices, 30 billion, 3 billion and 3 million years. Most were quite certain 3 thousand was not correct. All groups except physics favored the correct choice of 3 billion but no more than 35% of any group selected the correct answer.

Not more than 21% of any group stated that the great mountain ranges, such as the Rockies and the Alps, were once part of the floor of shallow seas.

The answers to two of the chemistry questions were quite surprising; 51% of those having taken chemistry selected for the reason motor

cars give off carbon monoxide, "some of the carbon dioxide present has been oxidized." Only 26% of this group chose, "there has been incomplete combusion in the motor."

Most students of all groups agree that the purpose of chlorinating a city water supply is to kill bacteria although 26% of the non-science group and 20% of the chemistry group chose "precipitate suspended impurities."

Concerning fundamental concepts in chemistry the following item was included: "A piece of wood is weighed and then burned. If the ashes and the gases given off (smoke etc.) are collected and weighed together, they will weigh (1) more than the original wood, (2) less than the original wood, (3) the same as the original wood." Only 29% of the chemistry group answered it correctly, 29% chose less than the original wood, 35% the same as the original wood and 7% left it out; 64% of those with both physics and chemistry chose "the same as the original wood." Only 5% of this latter group answered it correctly. Most students are aware that carbon dioxide is a product of burning.

The relatively poor showing of the high school physics and chemistry students throughout the examination may be the result of a combination of factors, such as poor high school science instruction, inability to read and understand, and normal loss in retention following the high school work. High schools have traditionally blamed the grade schools for inadequate basic instruction and colleges in turn have made similar accusations concerning the secondary schools. It will be interesting to learn from the third part of this study the loss in retention occurring between the college physical science course and graduation. This period is usually two to three years and corresponds favorably with the period between the student's high school science and his college work. It may well be found that the retention is no better. If so, it will suggest either a greatly improved college instructional program or the substantiation of a college education by reliance on so-called intangibles rather than on a gain in the facts and concepts of subject matter.

The pre-test summary is presented as follows[2]:

[2] The author would be interested in the results of this test given to any college group either in the State of Florida or in other parts of the country.

ANALYSIS OF PHYSICAL SCIENCE PRE-TEST

SEPTEMBER, 1949

Florida State University
Tallahassee, Florida

NAME_____

SCIENCE TAKEN IN HIGH SCHOOL

(Check the science you have taken—*Do not* include freshman high school science.)

Physics_____Chemistry_____Biology_____Other_____

SCIENCE TAKEN IN COLLEGE

(Indicate number of hours of college science, if any.)

Physics_____Chemistry_____Astronomy_____

Geology_____ Meteorology_____

Mark only one correct answer for each multiple choice question.

	HIGH SCHOOL SCIENCE				
	TOTAL GROUP	PHYSICS IN HIGH SCHOOL	CHEMISTRY IN HIGH SCHOOL	PHYSICS & CHEMISTRY IN HIGH SCHOOL	NEITHER PHYSICS NOR CHEMISTRY IN HIGH SCHOOL
1. The major cause of day and night as we experience it, is.....	%	%	%	%	%
1. the revolution of the earth around the sun....	35	36	39	26	34
2. the revolution of the moon around the earth..	2	3	2	5	2

3. the rotation of the earth on its axis	57	57	53	66	57
4. the phases shown by the moon (i.e. full, half, new, etc.)	0	0	0	0	1
%who omitted question	6	4	6	3	6
2. The reason most fully explaining why the moon shows phases (full, half, new, etc.) to the earth is that the					
1. moon shines by its own light, that is, light which it produces	2	0	4	2	1
2. moon rotates on its axis	10	9	13	7	11
3. moon revolves around the earth	42	51	41	45	34
4. earth rotates on its axis	11	3	13	10	16
5. earth rovolves around the sun	19	21	12	24	22
% who omitted question	16	16	17	12	16
3. Planets and stars differ in that					
1. stars are smaller than planets	15	12	19	12	14
2. stars shine by light they produce while planets do not	49	54	46	57	41
3. planets are at great distances from the earth while stars are at relatively short distances	7	6	6	7	9
4. planets more closely resemble the sun in size and physical characteristics	13	12	14	7	18
5. planets twinkle while stars do not	3	6	4	2	3
% who omitted question	13	10	11	15	15

PHYSICAL SCIENCE PRE-TEST—(Continued)	TOTAL GROUP	PHYSICS	CHEMISTRY	PHYSICS AND CHEMISTRY	NEITHER PHYSICS NOR CHEMISTRY
4. Comets					
1. are the same thing as "shooting stars"	31	51	21	31	23
2. have orbits about the sun	22	12	32	21	19
3. have tails which always extend behind them	27	27	24	26	34
4. are massive objects comparable in "weight" to the sun	7	3	1	10	13
% who omitted question	13	7	22	12	11
5. One of the following common weather axioms has a scientifically accurate basis. It is:					
1. A cold winter may be predicted by the actions of wild animals	13	15	12	12	14
2. A halo around the moon often indicates coming cloudy weather	53	51	59	52	50
3. A thunderstorm always brings a period of cool weather	8	12	4	14	5
4. Red sun at night sailor's delight,—red in the morning, sailors take warning	14	15	11	10	8
% who omitted question	12	7	14	12	13
6. The winds blow chiefly because of					
1. unequal heating of the earth's surface	64	78	58	69	60

2. force of gravity	7	6	4	10	8
3. inclination of the earth's axis	3	0	6	2	5
4. rotation of the earth on its axis	7	3	8	10	6
% who omitted question	17	13	24	9	21
7. On the passage of a cold front					
1. the weather turns colder	16	12	9	26	18
2. it usually rains for several days	8	9	9	10	4
3. there is a widespread area of general cloudiness and fog, but little rain	23	33	21	16	23
4. the wind usually blows from the south	6	6	6	7	4
5. the barometer reading is usually lower than before the passage	16	15	22	10	17
% who omitted question	31	25	33	31	34
8. A high pressure area is an area					
1. of bad weather	12	24	5	12	9
2. of generally rising air	34	24	36	40	34
3. of air with a clockwise motion around the center of the area	29	30	31	21	33
4. with movement from east to west	5	6	4	5	4
% who omitted question	20	16	24	22	20
9. The correct statement is:					
1. It is easier to float in water 30 feet deep than in water 10 feet deep	8	12	5	2	11

PHYSICAL SCIENCE PRE-TEST—(Continued)	TOTAL GROUP	PHYSICS	CHEMISTRY	PHYSICS AND CHEMISTRY	NEITHER PHYSICS NOR CHEMISTRY
2. A table is submerged in a swimming pool. If you swim under the table, there is less water pressure on you than if you are at the same depth, but not under the table.....	7	12	7	2	9
3. Tin foil wadded into a ball sinks, but the same piece shaped as a boat will float.....	54	57	53	65	41
4. An ice cube is floated in a glass of water. Water is added until glass is full to the brim. The water will overflow as the ice cube melts..	23	15	28	24	25
% who omitted question	8	4	7	7	14
10. One major reason an electric household refrigerator cools is because					
1. the presence of a substance in solution causes a liquid to freeze at a lower temperature.....	14	12	15	10	17
2. gas cools on expanding.....	14	12	7	33	5
3. cool air is capable of holding less water vapor than warm air.....	11	15	13	5	13
4. liquefied ammonia gas is capable of holding less heat than an equal weight of water vapor	37	39	44	33	32
% who omitted question	24	22	21	19	33

11. The greatest speed of those listed below is the speed of					
1. the earth in its orbit around the sun	2	3	3	2	2
2. sound	16	12	26	2	22
3. a rifle bullet as it leaves the gun	2	3	2	0	1
4. the sun as it travels through space	1	0	0	5	1
5. light	75	75	65	88	72
% who omitted question	4	7	4	3	2
12. A pure blue carpet in pure yellow light appears					
1. blue	4	9	0	5	4
2. yellow	4	3	4	2	1
3. green	79	78	85	74	82
4. black	3	0	5	5	3
5. red	2	3	2	2	1
% who omitted question	8	7	4	12	9
13. If you are near-sighted or far-sighted this condition is present because					
1. the iris of the eye does not admit the correct amount of light	11	12	9	8	12
2. the ball of the eye becomes lengthened or shortened, as the case may be	17	15	26	14	14
3. the retina (screen in the back of the eye) is no longer as sensitive as before the condition developed	7	9	10	7	4

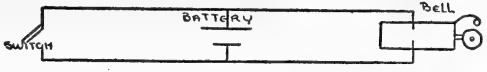
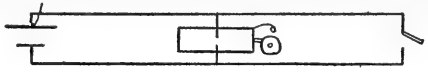
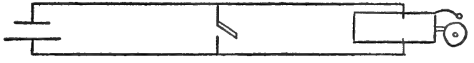
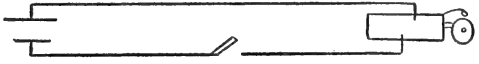
PHYSICAL SCIENCE PRE-TEST—(Continued)	TOTAL GROUP	PHYSICS	CHEMISTRY	PHYSICS AND CHEMISTRY	NEITHER PHYSICS NOR CHEMISTRY
4. the lens of the eye has developed an irregular curvature	31	39	20	36	30
5. the muscles of the lens of the eye no longer control properly the thickness of the lens	19	12	17	26	20
% who omitted question	15	13	18	9	20
14. The principle by which the northern lights produce their light is similar to the operating principle of					
1. a neon lamp	12	12	9	17	10
2. fluorescent paint	34	33	39	38	27
3. the filament electric lamp	8	12	10	7	7
4. the flame of a match	7	9	5	2	9
% who omitted question	39	34	37	36	47
15. The human eye resembles an adjustable camera in respect to					
1. the means of focusing for objects near and far	37	24	47	36	39
2. the general nature of the action which forms the image	39	51	33	40	32
3. utilization of ultraviolet light	1	0	1	2	3

4. the fact that the image formed by the lens is erect with respect to the object viewed.....	11	15	12	10	8
% who omitted question	12	10	7	12	18
16. The temperature at which water freezes on the CENTIGRADE scale is					
1. 100	4	0	5	7	4
2. 0	65	78	59	81	43
3. 32	16	12	18	7	27
4. –32	8	6	13	2	10
% who omitted question	7	4	5	3	16
17. The resistance of a circuit carrying an electric current may be increased appreciably by					
1. inserting a fuse.....	11	9	10	12	14
2. decreasing the diameter of the conductor....	26	39	17	36	12
3. shortening the connecting wires.....	4	6	7	0	2
4. increasing the voltage.....	28	27	30	24	29
% who omitted question	31	19	36	28	43
18. Sound cannot travel through a					
1. liquid.....	7	3	7	7	12
2. solid.....	6	6	7	0	11
3. gas.....	1	0	0	0	3
4. vacuum.....	77	87	75	88	60
% who omitted question	9	4	11	5	14

PHYSICAL SCIENCE PRE-TEST—(Continued)	TOTAL GROUP	PHYSICS	CHEMISTRY	PHYSICS AND CHEMISTRY	NEITHER PHYSICS NOR CHEMISTRY
19. The correct statement is:					
1. In a vacuum a feather falls more slowly than a piece of lead	8	6	13	5	8
2. If you have a glass straw 100 feet long and stand on a bridge 90 feet above the water you can suck water into your mouth provided you are given sufficient time to do so	8	3	10	5	15
3. If a bullet is shot horizontally from a gun and one dropped from the same height at the same instant, the one dropped will strike the ground sooner than the one shot from the gun	7	6	9	0	11
4. The farther you are from the center of the earth the less you will weigh (using a spring balance for the determination)	23	27	15	38	14
5. You expend less effort if you carry a stone up a gently inclined stairway than if you carry it to the same height up a vertical ladder	36	45	30	38	32
% who omitted question	18	13	23	14	20
20. The atoms of a given element may differ in atomic weight, have different physical characteristics and yet not vary chemically. This is because of a variation in the number of their					

1.	neutrons	22	12	20	29	25
2.	electrons	35	33	48	38	22
3.	protons	10	12	11	7	10
4.	positrons	0	0	0	0	1
5.	negatrons	0	0	0	0	0
	% who omitted question	33	43	21	26	42
21.	An atom or a group of atoms bearing an unbalanced electrical charge is called					
1.	an electron	14	18	8	14	17
2.	a molecule	11	9	6	10	12
3.	an isomer	3	3	5	0	3
4.	an isotope	11	12	13	14	8
5.	an ion	31	24	40	40	23
	% who omitted question	33	44	28	22	37
22.	The smallest particle of those listed is					
1.	atom	39	51	36	24	46
2.	molecule	19	12	24	12	26
3.	proton	32	24	35	55	17
	% who omitted question	10	13	5	9	11
23.	The particle listed below having the smallest mass (weight) is					
1.	atom	23	24	32	20	18
2.	electron	26	24	18	48	17

PHYSICAL SCIENCE PRE-TEST—(Continued)	TOTAL GROUP	PHYSICS	CHEMISTRY	PHYSICS AND CHEMISTRY	NEITHER PHYSICS NOR CHEMISTRY
3. proton	9	0	14	10	11
4. molecule	16	18	19	0	25
% who omitted question	26	34	17	22	29
24. The most comfortable of the following values of relative humidity to the human is					
1. 0	1	3	1	0	0
2. 10	1	0	1	0	4
3. 20	15	18	20	14	11
4. 60	55	54	54	50	57
5. 100	1	3	0	0	2
% who omitted question	27	22	24	36	26
25. During a thunderstorm the safest place to stay (of those mentioned below) is					
1. in the middle of a large, open, level field	47	39	56	40	50
2. under a tree in the middle of a large, open field	0	0	1	0	0
3. in the bathtub	1	0	1	4	0
4. in a wooden building	29	33	25	31	30
5. inside a trailer made entirely of steel	13	12	13	9	16
% who omitted question	10	16	4	16	4

26. In which instance will closing the switch cause the bell to commence ringing?					
1. 	16	9	21	14	18
2. 	11	6	12	10	16
3. 	8	6	10	7	7
4. 	30	45	16	46	15
% who omitted question	25	35	41	23	44
27. You burn a 100 watt lamp 40 hours. At 10 cents a kilowatt hour the cost is					
1. 40 cents	38	42	37	45	26
2. $4.00	18	15	19	15	22
3. 4 cents	17	15	17	21	17
4. $400	2	3	1	0	3
5. $40	1	0	3	0	2
% who omitted question	24	25	23	19	30

PHYSICAL SCIENCE PRE-TEST—(Continued)	TOTAL GROUP	PHYSICS	CHEMISTRY	PHYSICS AND CHEMISTRY	NEITHER PHYSICS NOR CHEMISTRY
28. Water is often carried in canvas waterbags by desert travelers. Water seeps through these waterbags at a slow rate. Concerning this seepage it is known that					
1 the desert temperature is so high that the water expands considerably. The water seeping through the bag acts as a safety valve to prevent the bag from bursting.....	14	12	17	5	18
2. the water as it seeps to the surface of the bag is evaporated, and the evaporation keeps the remainder of the water moderately cool.....	53	69	48	57	38
3. the seepage accumulates dust on the wet bags and so improves the heat insulation.....	5	6	4	7	5
4. the seepage has no value but is present only because of the imperfection of the bags.....	10	6	12	10	13
% who omitted question	18	7	19	21	26
29. The correct statement is:					
1. Earthquakes can be predicted with a high degree of accuracy.....	11	6	12	10	14
2. Earthquakes can be predicted with a moderate degree of accuracy.....	26	24	31	19	26

3. Earthquakes cannot be predicted with any appreciable degree of accuracy	53	63	48	55	53
% who omitted question	10	7	9	16	7
30. The age of the earth is considered to be about					
1. 30 billion years	26	27	24	24	29
2. 3 billion years	28	18	35	29	30
3. 3 million years	17	27	16	12	14
4. 3 thousand years	3	3	4	0	4
% who omitted question	26	25	21	35	23
31. On the basis of present mining and refining techniques and prices, of the mineral substances listed below, the one found in greatest reserve in the United States is					
1. coal	55	63	52	52	52
2. iron	14	18	14	12	14
3. aluminum	11	12	12	14	8
4. copper	8	3	9	10	8
% who omitted question	12	4	13	12	18
32. Of the mineral substances listed below, the one in shortest supply in the United States is (This question is to be answered on the basis of present mining and refining techniques and prices)					
1. coal	17	12	24	17	14

PHYSICAL SCIENCE PRE-TEST—(Continued)	TOTAL GROUP	PHYSICS	CHEMISTRY	PHYSICS AND CHEMISTRY	NEITHER PHYSICS NOR CHEMISTRY
2. iron	8	3	10	7	8
3. aluminum	27	39	31	14	25
4. copper	28	27	19	43	26
% who omitted question	20	19	16	19	27
33. The one correct statement is:					
1. Our great mountain ranges, such as the Rocky Mountains and the Alps, were once part of the floors of shallow seas	19	21	21	19	15
2. It is believed by most geologists that volcanoes draw their molten lava from near the center of the earth	34	42	30	28	36
3. Alley Oop and his tamed dinosaur have certain plausible aspects in that dinosaurs and ancient man lived at the same time	10	18	6	10	6
4. Birds evolved from mammals	3	3	4	5	2
5. Most geologists believe the Atlantic Ocean was once occupied by a continental mass which connected the continental masses of North America	17	3	22	21	17
% who omitted question	17	13	17	17	24
34. The phrase "fixation of nitrogen" means					
1. obtaining the gas from nitrates	5	3	4	12	1

2. converting sodium nitrate into nitric acid....	4	3	3	5	4
3. nitrating an organic compound.....	89	16	8	5	7
4. liquefying air to obtain the oxygen.....	4	6	5	2	4
5. converting the nitrogen of the air into soluble compounds.....	33	36	37	33	25
% who omitted question....	45	37	43	43	59
35. The reason that motor cars give out carbon monoxide is that					
1. some of the carbon dioxide present has been oxidized.....	40	33	51	31	45
2. there has been incomplete combustion in the motor.....	29	30	26	41	17
3. the fuel used has not enough fixed carbon....	3	3	4	2	4
4. the fuel used did not have enough hydrocarbon.....	3	3	3	5	1
% who omitted question....	25	31	16	21	33
36. The United States depends upon other countries for a major portion of its					
1. tin.....	53	57	59	47	50
2. bromine.....	12	9	15	10	14
3. sulphur.....	5	9	0	7	3
4. phosphate.....	6	3	8	9	4
5. "fixed" nitrogen.....	6	9	4	7	4
% who omitted question....	18	13	14	20	25

PHYSICAL SCIENCE PRE-TEST—(Continued)	TOTAL GROUP	PHYSICS	CHEMISTRY	PHYSICS AND CHEMISTRY	NEITHER PHYSICS NOR CHEMISTRY
37. The purpose of chlorinating the water supplied to cities is to					
1. add desirable mineral salts to the water.....	1	0	2	0	0
2. soften the water.....	0	0	0	0	0
3. precipitate suspended impurities.....	15	9	20	7	26
4. improve the laundering qualities of the water.	1	0	0	0	1
5. kill bacteria.....	75	78	74	83	64
% who omitted question....	8	13	4	10	9
38. Copper, silver, and gold were known and used long before iron. This may be explained, at least in part, by considering that					
1. iron does not occur on the earth's surface....	12	12	15	10	10
2. iron did not have as many uses as copper, silver, and gold.....	5	9	0	5	4
3. copper, silver and gold occur as free metals and iron is always combined in the form of some compound.....	25	21	34	29	18
4. copper, silver and gold are easier to separate from their compounds than is iron.....	32	39	28	33	31
5. iron occurs chiefly in the United States and North America was not civilized as early as					

were the other continents.....	9	0	11	9	14
% who omitted question....	17	19	12	14	23
39. A piece of wood is weighed and then burned. If the ashes and the gases given off (smoke etc.) are collected and weighed together, they will weigh					
1. more than the original wood.....	15	12	29	5	14
2. less than the original wood.....	32	33	29	26	39
3. the same as the original wood.....	41	39	35	64	26
% who omitted question....	12	16	7	5	21
From the key below select the gas which most closely answers the statement.					
(1) Hydrogen (2) Oxygen (3) Nitrogen (4) Chlorine (5) Carbon dioxide					
40. Is the lightest					
1.	64	51	77	83	44
2.	7	6	2	5	16
3.	9	18	11	5	2
4.	2	3	0	0	6
5.	0	0	0	0	0
% who omitted question....	18	22	10	7	32

PHYSICAL SCIENCE PRE-TEST—(Continued)	TOTAL GROUP	PHYSICS	CHEMISTRY	PHYSICS AND CHEMISTRY	NEITHER PHYSICS NOR CHEMISTRY
41. Makes up the greatest percentage of the air which we breathe					
1.	11	21	7	9	8
2.	53	45	63	41	64
3.	19	15	20	31	11
4.	0	0	0	0	0
5.	3	0	5	0	8
% who omitted question	13	19	5	19	9
42. Is a product of burning					
1.	4	6	3	0	5
2.	8	0	6	10	18
3.	6	6	10	7	2
4.	0	0	0	0	0
5.	70	75	77	71	60
% who omitted question	11	13	4	12	15
43. Is that part of the air which is directly used by the body as a result of breathing					
1.	5	3	7	0	9
2.	69	72	63	81	62

3.	5	9	9	0	4
4.	1	0	3	0	0
5.	9	6	13	5	13
% who omitted question	11	10	5	14	12
44. Will burn in air					
1.	23	24	24	33	12
2.	4	0	6	5	4
3.	32	42	27	26	34
4.	13	9	22	7	11
5.	4	6	0	0	12
% who omitted question	24	19	21	29	27
For items 46 to 49 select from the key the field most closely related to the widely known scientist.					
1. Astronomy 2. Geology 3. Chemistry 4. Physics					
J. R. Oppenheimer					
1.	6	12	4	0	6
2.	8	9	7	7	9
3.	7	9	9	5	4
4.	17	18	10	17	24
% who omitted question	62	52	70	71	57

PHYSICAL SCIENCE PRE-TEST—(Continued)	TOTAL GROUP	PHYSICS	CHEMISTRY	PHYSICS AND CHEMISTRY	NEITHER PHYSICS NOR CHEMISTRY
46. Arthur H. Compton					
1.	6	6	8	0	7
2.	7	12	10	0	7
3.	9	9	8	12	0
4.	8	15	8	5	6
% who omitted question	70	58	66	83	74
47. Harlow Shapley					
1.	9	15	12	7	4
2.	5	6	7	0	5
3.	8	12	5	5	8
4.	4	3	6	5	4
% who omitted question	74	64	70	83	79
48. Don Leet					
1.	5	6	4	5	6
2.	7	12	9	7	4
3.	5	3	10	0	5
4.	5	15	5	0	5
% who omitted question	78	64	72	88	..
For items 50 to 52 select from the key the most closely related scientist					

1. Galileo 2. Ptolemy 3. Copernicus 4. Aristotle					
49. First saw the moons of Jupiter					
1.	27	39	24	24	23
2.	11	12	8	7	12
3.	17	15	17	5	33
4.	6	9	5	5	6
% who omitted question	39	25	46	59	26
50. Widely known for his theory that the planets revolved around the sun					
1.	15	12	18	10	18
2.	10	12	4	12	11
3.	18	27	20	7	19
4.	16	27	9	14	16
% who omitted question	41	22	49	57	36
51. Widely known for his theory that the earth was the center of the solar system, the planets, moon and sun revolving around the earth					
1.					
2.					
3. No analysis					
4.					
% who omitted question					

FLORIDA ACADEMY OF SCIENCES

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THE RANGE OF THE FLORIDA MANATEE

JOSEPH CURTIS MOORE

Everglades National Park

As an outgrowth of an earlier paper on the status of the manatee, *Trichechus manatus latirostris* Harlan, in the Everglades National Park the writer has compiled the following account of this animal's present distribution. Brown (1878, p. 293), Nelson (1916, p. 465), Anthony (1928, p. 555), Hatt (1934, p. 538), Gunter (1941), Cahalane (1947, p. 630) and others have described the Florida manatee's range on the basis of information available to them. The present paper deals with the matter in greater detail and requires revision of earlier conceptions of the animal's range. By designating on the distribution chart (Figure 1) the observations made during the years 1941 to 1951, not only a fairly contemporary distribution, but also some indication of present status throughout the animal's range is sought. It should be pointed out that there seems to be a good possibility of future increase in this animal's numbers, since, for one thing, the growing influence of organizations interested in conserving natural resources will probably obtain better enforcement of the State law which protects it. For another, ranger patrols in the Everglades National Park offer the animal more nearly complete protection in an area of its habitat large enough to support a considerable herd.

The distribution indicated on the chart is, of course, biased by the range of the writer's activities and acquaintance, and somewhat by the distribution of interested and competent observers. To provide, therefore, for proper evaluation of Figure 1, the sources of information are described and discussed below. All localities mentioned in this paper are for Florida unless otherwise indicated.

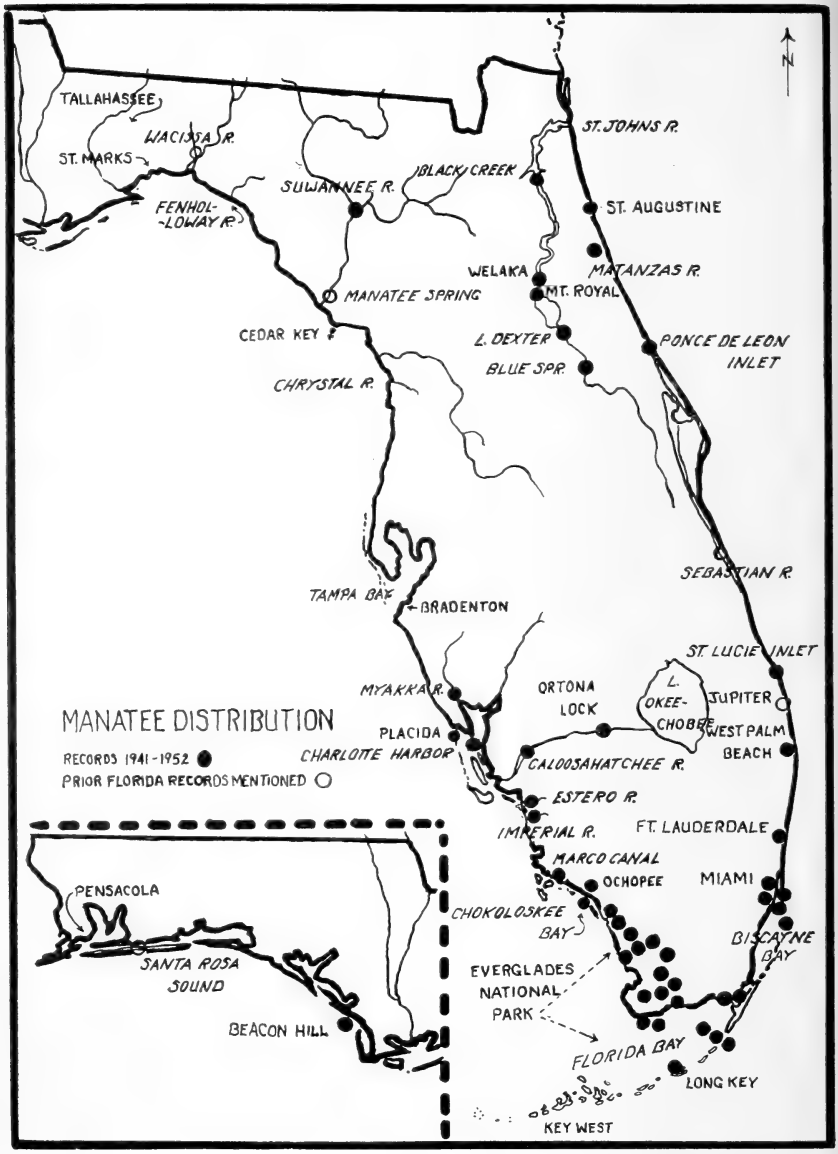

Figure 1.—The contemporary distribution of manatees in Florida, showing Florida localities and records mentioned in this paper.

Acknowledgments

It is a pleasure to acknowledge encouragement derived from the sustained interest of park superintendent Daniel B. Beard. Gratitude is expressed to Chief Naturalist John E. Doerr of the National Park Service who encouraged me to go ahead with this work. Park Warden M. Barney Parker's keen interest in the wildlife of the Everglades National Park, which he is so actively protecting, has produced in his park patrol log a store of observations of the manatee which has been liberally drawn upon here. Henry W. Setzer most generously provided certain skull measurements from manatee material in the United States National Museum. Through the agency of Professor Ezra Allen of Stetson University, the writer received several splendidly reported and important observations from Roswell Bushnell III of DeLand. Fisheries biologist William M. McLane with most generous perserverance obtained records from his colleague Barry O. Freeman and others, and provided them carefully in letters of June 11, 1950, February 7, March 27, April 13 and 30, 1951. Stewart Springer, a marine fisheries biologist of wide experience in Florida waters, contributed valuable observations and comment in a letter of April 3, 1950. To these and to others whose contributions will be mentioned in the following account, the writer is very grateful.

Distribution in South Florida

Near the southern tip of the mainland of Florida there are two foci of greatest manatee abundance. One is on the east coast in the northern part of Biscayne Bay and the rivers, creeks, and canals which open into this bay. Curiously, this is in and bordering upon metropolitan and suburban Miami, with the greatest numbers of animals being seen in the Miami River in the very heart of the city. Here the writer (1951, p. 25) has seen concentrations exceeding ten individuals on very cold mornings gathered in the outflow of a factory outlet where it vents warm water into the river beneath the Miami Avenue Bridge. West Archer of Coconut Grove told the writer that while he was an inspector for the city of Miami on the deepening of the Miami River channel in about 1943, he personally saw enough carcasses of manatees killed by dynamiting of rock in the river bed to provide a basis

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for an estimate of one hundred killed during the whole affair. Certainly no other city in the world can boast a population of free, wild manatees; yet as publicity conscious as Miami is, no overt effort is being made to acquaint visitors with the presence of this rare and interesting marine mammal.

The other focus of abundance is in the bays and rivers of the west coast of the Everglades National Park. In eleven months of patrolling by outboard motor in 1950 in this area, Parker recorded in his park patrol log thirty-one observations of manatees. Local distribution of these and additional observations recorded by others of the ranger staff and the writer are suggestive of the animal's relative geographical abundance locally: Whitewater Bay, mostly eastern part, and rivers emptying into it, 25; Shark River system, 11; Broad and Rogers rivers system, 14; and Lostmans River system, 4. Since patrolling of these extensive and intricate waterways has been much more intensive in the Shark, Broad, Rogers, and Lostmans Rivers area than in eastern Whitewater Bay and its attendant rivers, it is apparent that manatees are much more abundant in the latter area. It should be borne in mind that the manatees in the area of the newly established Everglades National Park reflect their recent unlawful persecution by meat-hungry commercial fishermen by being very shy. Furthermore, virtually all of these observations have been made from boats driven by noisy outboard motors. It is felt that many more individuals escape observation by remaining hidden on the bottoms of these turbid rivers and bays than attract attention to themselves by frightening up and swimming violently away. Many of the records for the Park area have been reported earlier by the writer (*op. cit.*, p. 23) and require no elaboration here.

In recent historical times manatees of the two above described herds have probably had little opportunity to mix. They are separated artificially by the long, shallow expanse of Florida Bay which has been intensively fished for years by commercial fishermen who rather freely risked the $500 fine to slaughter these animals for food. The sixteen miles of open Gulf of Mexico to round Cape Sable would provide no great additional barrier, since the water is usually turbid there.

No reports of manatees farther down the Florida Keys than the bay side of Long Key (lat. 24° 50′) have reached me. Springer

comments (letter, Apr. 3, 1950), "On the negative side it may be of some interest that I have never seen a manatee in the Keys away from the mainland although I have spent a lot more time there than along the mainland. . . ." It may be that clarity of the water and lack of freshwater streams inhibit manatee dispersal down the Keys.

Distribution Up the East Coast

Proceeding northward from Biscayne Bay on the east coast, we find the manatee well known in the New River (lat. 26° 08′) in the heart of the town of Fort Lauderdale. Keepers of two bridges, a charterboatman who moored his boat in the river, and a retired doctor who lived beside the river all told the writer that they often see manatees. The writer (*op. cit.*, p. 28) mentioned manatee occurrence here in connection with breeding and (p. 34) here as well as farther north in the West Palm Beach Canal (lat. 26° 40′) in connection with food.

Springer provides the next record northward, "I saw a manatee in the pocket at Salerno [lat. 27° 09′] near the St. Lucie Inlet in the summer of 1948. This was a lone individual and very wary, and was accompanied by an entirely irrelevant otter, not a young manatee. I don't understand what I saw." McLane contributes the follow records for this locale. A. S. Dunham of Okeechobee saw a manatee on the 28th, 29th or 30th of December, 1948, in the Indian River one mile north of St. Lucie Inlet, moving along just at the surface of the water. On January 19, 1951, Dunham saw a manatee for perhaps ten seconds at the surface after the manatee attracted his attention by the sound of it "blowing" only fifty feet away. This was in water estimated to be 7 to 12 feet deep a quarter mile west of the inner end of the rock jetties of St. Lucie Inlet. John Henry Ausburn of Stuart, Florida, observed a manatee rise to breathe in north fork of the St. Lucie River about 12 miles up from the mouth of the river, on April 20, 1951.

From here north to Ponce de Leon Inlet I have been unable to obtain definite information, but from the geographical situation it seems reasonable to assume that manatees at least pass through those inland salt water lagoons known as Indian River, Banana River, and Mosquito Lagoon, and probably linger about these areas and venture especially up any navigable freshwater canals

and streams which open upon these, moving north and south mainly by the Intracoastal Waterway. Bushnell provides the following record, "June 23, 1949, Ponce de Leon Inlet, Volusia County [lat. 29° 05′] abnormally clear surf, surface mirror-like, tide two hours in-coming, five full-grown and one infant animals observed . . . my wife and I . . . were surf fishing . . . my attention was drawn to several unusual looking dark spots on the water just on the other side of the line of breakers rolling over a sandbar approximately 75 yards from the water's edge. Between this bar and the water's edge was a slough about six feet deep at its deepest part. . . . Five were large and one very small. They were moving toward shore, and as they crossed over the bar on a large wave, I identified them as manatee. They moved in quite close to shore and at times I was afraid that as the waves receded they would be momentarily left stranded. The animals were very close, and I ran into the water and tried to swim out among them. They moved away from me but did not seem to be very alarmed. . . . Later that week I heard that a man who runs a fishing camp south of Daytona on the Halifax River had harpooned and killed one manatee from a group of them that had come up near his boathouse. . . . I presume these were the same ones I saw."

Henry Kritzler, formerly of Marineland (letter, Nov. 9, 1950), comments, "I can state that they are fairly numerous in the Intracoastal Waterway and contiguous streams in the St. Augustine area during the spring, summer and fall. I remember well watching five of them . . . in the moonlight in the south branch of the Matanzas River [lat. 29° 39′] in the first week in November, 1948." In a further letter of January 4, 1951, he emphasizes that it was during the warm months of the year ". . . that we saw them regularly in the Intracoastal Waterway."

C. R. Vinten, coordinating superintendent of the southeastern National Monuments, writes (letter, February 21, 1951), "During the summers of 1942-43-44, manatees were frequently seen from my dock in St. Augustine. There was no doubt about the identification as the dock ran 400 feet out in Matanzas Bay to the channel edge, and the creatures passed almost underfoot. They were seen singly, once in a pair, and once a cow with a calf about four feet long. After the long dock was removed by the 1944 hurricane, I occasionally saw one specimen during the summer

feeding in shallow waters at high tide nearby. This was in 1948-49. . . . No winter observations can be recalled, so I presume they move southward in cold weather."

Regarding the possibilities of manatees on the Georgia coast the comment (letter, Nov. 26, 1950) of Ivan R. Tomkins of Savannah, is interesting. "Speaking of Georgia rivers generally, we have five, the Savannah, Ogeechee, Altamaha, Satilla, and St. Marys. The Savannah and Altamaha are both through rivers, originating above the Fall Line and carrying heavy loads of silt from the piedmont. They are therefore very muddy rivers, without any great amount of underwater vegetation, and it seems doubtful if the manatee would spend any time in them. The others, Ogeechee, Satilla, and St. Marys are 'black-water' rivers and entirely different in character. The Ogeechee is fished a lot along its entire length, and one would expect reports of any such large mammal if present. I have never heard any mention of manatees in them. Still, I am not always in a position to hear fisherman tales."

In North Carolina H. H. Brimley (1931, p. 320) reported a seven-foot two-inch manatee captured by fishermen in Masonboro Sound (lat. 34° 15′) near Wilmington on September 11, 1919. Sex was not noted, but the skin was deposited in the State Museum at Raleigh, N. C. C. S. Brimley (1946, no page) contributes, "A second specimen was taken alive in Currituck Sound near Duck Island (lat. 36° 20′) about the middle of October, 1934, length 10 feet, weight estimated 1,000 pounds."

McAtee (1950, p. 98) brings to our attention an early observation published by Thomas Glover (1676) of an animal which must have been a manatee, in the Rappahannock River about 10 miles from its mouth (lat. 37° 38′), in Virginia.

Distribution Up Florida West Coast

On the west coast of Florida north of the present boundary of the Everglades National Park, lies an area of rivers and bays similar to and continuous with that in the Park and probably of nearly equal appeal to the manatee. According to several local commercial fishermen familiar with that area, the Chatham Bend River and Houston River are good places to look for sea cows, whereas in the Lopez and Turner Rivers just north of them the animal is rarely known to occur. This latter scarcity relates to the

proximity of the mouth of the Lopez and Turner Rivers to the island of Chokoloskee which has been inhabited by several generations of low subsistence fishermen.

Art Eiffler, charterboatman of Everglades, told the writer of seeing a large manatee lying on the bottom in shallow water in Chokoloskee Bay (lat. 25° 51′), Collier County, in the summer of 1949. Several residents of Ochopee, Collier County, and a State highway patrolman told the writer on September 4, 1950, of a manatee having been killed the week before in the canal beside the Tamiami Trail (U. S. highway No. 94) just 1.2 miles west of its junction with the Everglades-Immokalee road (Florida route No. 29). The canal is well connected with the sea there and is tidal. Occurrence of manatee in the highway canal, however, was regarded by the local people as most unusual. Robert M. Bowers of Marco Island told me of seeing a manatee in the canal beside the road which connects Marco Island with the Tamiami Trail (lat. 25° 57′), and knew definitely of one which had been killed there in November of 1949.

On November 26, 1950, William Piper, the well-known animal man of Bonita Springs, Lee County (lat. 26° 19′), told me of having seen a manatee in the Imperial River on several occasions about 1948 up river from the highway bridge in Bonita Springs. On the same day a gasoline station operator beside the Estero River in Estero, Lee County (lat. 26° 25′), told me that manatees occasionally came up the river seven miles to that place and that he had seen one about three weeks before. He mentioned one which had recently been shot in the river and allowed to rot.

Hamilton (1941, p. 690) reports a ten-foot female manatee found ten miles above Fort Myers up the Caloosahatchee River. This is 27 miles up from the mouth of the river. Fred A. Flanders of Moorehaven (letter, March 1, 1951) states that he saw a manatee in the Caloosahatchee, " . . . just below Olga where the river widens out into the lower bay. It was some distance from shore but upon the approach of the boat it disappeared. . . ." The river widens out into the lower bay just 20 miles above the mouth. Flanders also relates, however, that R. W. Collier, an employee of his, walked up on a manatee which was, ". . . feeding in some hyacinths . . . about one mile above Ortona Lock in a slough coming into the river from the south." This locality is about 54

miles up the Caloosahatchee River. Regarding the possibility of manatee occurrence 23 miles farther up the river in Lake Okeechobee Flanders comments, "In my 30 years of exploration in and around Lake Okeechobee I have never seen a manatee; neither have I come in contact directly with anyone who has. . . . However, I might say that there is no physical barrier or reason for the manatee not to be in the waters of the lake. . . . Their occurrence however in this area is rare." McLane writes that Coleman Tousey of Summerville, Massachusetts, saw a dead manatee of adult size floating in the Caloosahatchee River between Olga and Fort Myers in 1949, probably between January and March, and in mid-March of 1951 another dead, adult-size manatee in the same locality. "He commented several times about how rare they were getting now because so many people shot them. . . ."

Dan Evans, operator of a fishing camp near the mouth of the Myakka River for 18 years, told me that he used to see many manatees in the Myakka River, but that it had been five years since he had seen one. He said that a small group had been seen at Placida, Charlotte County (lat. 26° 49′) during the summer of 1950.

Springer contributes, "I have seen manatees, singly and in small groups in Lemon Bay (lat. 26° 56′) and Charlotte Harbor, but I do not remember dates . . . it would be before 1941. . . . Back in about 1938 we had a manatee, and adult female with no embryos, brought into the laboratory dock at Englewood. It had been in a net in Lemon Bay . . . shot so that it was disabled. . . . Perhaps the only reason that it was taken was that it was incapable of normal swimming."

Herbert R. Mills, medical doctor and naturalist of Tampa, writes (letter, November 6, 1950), "I have made inquiries of old timers in this vicinity, and I am convinced that no competent observer has reported a manatee in Tampa Bay or any of its tributaries since 1912 when one individual was reported by local fishermen near the mouth of the Manatee River." From ten months of work on the plankton of the Florida west coast in 1949, fisheries research biologist Joseph E. King writes (letter, Oct. 31, 1950), "I did not see any manatees . . . in Florida waters . . . and I am certain also that none had been seen by other members of the Laboratory (Sarasota) staff during the same period."

On the Cedar Key area Paul G. Pearson, University of Florida, comments (letter, Oct. 13, 1950), "I have asked around and have as yet to find the first evidence of manatee around Cedar Key." Kirk Strawn of the same institution carries this further (letter, Dec. 4, 1950), "Cedar Key is evidently outside of its range. I asked about six fishermen between about 30 and 60 years old if they had ever seen one around Cedar Key. All these fishermen said no. One said they didn't come north of Manatee River; another said several people had seen one at Crystal River. . . . The area these fishermen know is from St. Marks to Crystal River. Two had spent much time about the mouth of the Suwannee."

From the vicinity of Tallahassee, Herbert L. Stoddard writes, "I have no information on the manatee being seen along the Gulf Coast of northern Florida in the twenty-six years that I have lived in this section. As I am not much of a mammalogist, and make no serious attempt to keep posted on the mammals, I asked my friend and associate E. V. Komarek . . . and he informs me that he had no information about the manatee in this region, either."

From the St. Marks Wildlife Refuge, Wakulla County, Paul T. Kreager writes (letter, February 20, 1951), "I have been at this station intermittently since 1931 and as yet I have seen no manatee and have talked with no one who has. I am speaking . . . of the area north of the Fenholloway River."

T. R. Hodges of Cedar Key writes (letter, March 16, 1951) . . . they became almost extinct years ago. . . . A law was passed prohibiting anyone from taking or killing a manatee except for scientific purposes. . . . The enforcement of this law was under my jurisdiction for fifteen years and was rigidly enforced, and the manatee became very plentiful. I found them to be somewhat of a nuisance in navigation as they would get in the narrow canals and run for miles ahead of our boats, but at very slow speed and at times double back and attempt to pass under the boat. . . . I have never known a manatee to be north of Fort Myers to St. Marks or west of there on the Gulf."

H. B. Sherman (letter, May 26, 1951) learned in October of 1946, that R. D. Baymiller of Panama City saw a butchered manatee which had been killed by fishermen in six or seven feet of

water off Beacon Hill, Gulf County, lat. 29° 56′ and long. 85° 23′. Baymiller had obtained and eaten a portion of its flesh.

From the northwestern position of Pensacola, chief of Gulf Oyster Investigations Philip A. Butler responds (letter, Jan. 4, 1951), "I have delayed answering . . . in hopes of obtaining some definite information. We had no records concerning them here in the laboratory. I inquired of several local fishermen who had no knowledge of the manatee. Finally the sports editor of the local paper put an appeal for information in one of his columns. . . . No one here seems to know anything about the beast." There is no intent here to discredit Silas Stearns' story (True, 1884, p. 114) of a manatee seen in Santa Rosa Sound (lat. 30° 22′ and long. 86° 50′) twenty miles east of Pensacola, but the statements quoted for the Florida west coast in the present paper make it clear that such an occurrence is probably so rare as to be in a class with occurrences on the North Carolina or Virginia coast. Stearns' further statements regarding the general distribution of manatees from Key West to New Orleans are not regarded as based upon fact.

Migration

There is a legend among fishermen in northern peninsular Florida that the manatees migrate with the season north and south. A correspondent of Nelson's (1916, p. 465) at Ponce Park, Volusia County (lat. 29° 05′), informed him that the manatees were numerous there in 1916 and apparently seasonal, leaving about December and returning in late March. Migration is also strongly indicated in Vinten's and Kritzler's above-quoted comments on manatee occurrence in the St. Augustine area. Examination shows that every north Florida observation recorded (except those for certain rivers, to be discussed presently) is in the season of summer warmth. The northern extent of this animal's winter range for the east coast is suggested by its occurrence in the Sebastian River (lat. 27° 52′) in December and February of 1894-5 (Bangs, 1895, pp. 784, 785). The northern extent of its winter range on the west coast of Florida is suggested by its presence in numbers in Charlotte Harbor area (lat. 26° 45′) in January of 1940 (the writer, 1951, p. 35). The numerous warm-season records north of these are believed to represent a warm-season expansion of range to the north. The North Carolina, and possible Virginia records are be-

lieved to represent rare excesses of this warm-season movement. Individuals in these cases may easily wander beyond the limit of their ability to return to a safe latitude.

Gunter (1942, p. 89) indicates that this seasonal migration takes place on the Texas coast. "All animals reported from Texas in recent years were seen in the summer. Probably American manatees never winter north of areas normally free of cold waves. . . . This would preclude their presence in any part of Texas during midwinter."

It is interesting that no evidence of migration is available for the Florida west coast. The known winter northern extent of range approximates that of the summer. Park Warden Parker's patrol log may be scrutinized here to discover whether in the population in the Everglades National Park, a summer exodus takes place. By outboard motor boat Parker patrols the labyrinthine waterways of the mangrove coast to protect its wilderness character from vandalism of several sorts. He patrols religiously and records his observations of wild life methodically. First taking care to eliminate days that Parker patrolled in areas not frequented by manatees, we find that he patrolled the following number of days and saw the corresponding number of manatees for the months of 1950: January, 17 days, 1 manatee; February, 14 & 6; March, 14 & 4; April, 17 & 5; May, 16 & 6; June, 16 & 7; July, 11 & 2; August, 7 & 6; September, 1 & 1; October, 16 & 3; November, 18 & 3; and December, 16 & 11. Bunching these into rather conventional seasons, we obtain the following number of days patrolled per one manatee seen: December-January-February 2.6, March-April-May 3.1, June-July-August 2.3, and September-October-November 3.8. This appears to be good evidence that numbers of manatees stayed in the southern end of their range on the Florida west coast throughout the entire year of 1950, and it certainly does not suggest a summer exodus.

Distribution in North Florida Rivers

That the mouth of the St. Johns River (lat. 30° 24′) has been reached from time to time by manatees is indicated by a considerable number of records in that north flowing stream. Proceeding south, upstream, on the St. Johns River, our first records are from Freeman (McLane's letter, June 11, 1950). These are for Black

Creek, Clay County (lat. 30° 03′) where one was seen on April 1, 1949, and a group of five were seen about August, 1949. Freeman saw a manatee at Turkey Island about a mile south of Welaka about the middle of May, 1949. McLane wrote further, "Harold Huber . . . told me early in 1946 that he . . . saw some large objects in the water from their fishing camp . . . just south of Mt. Royal [lat. 29° 26′]. They . . . approached close enough to see and shoot at a sea cow. Five sea cows went charging off down the river after the shot was fired. . . . The Hubers first saw these seacows . . . over a shallow sand bar which was heavily vegetated with *Vallisneria americana*." The observation was sometime in 1945. The present writer (1946, p. 58) published several such accounts for this vicinity, the only dated one being for September. McLane (letter, April 13, 1951) adds that Barry O. Freeman observed a manatee in Croaker Hole Cove of this part of the river on January 20, 1951, and that Melvin Huish saw one that same month at the Mt. Royal Ferry.

Up river, south, from Lake George several records are provided by Bushnell, "September, 2nd week, 1949, southern entrance to Lake Dexter, Volusia County (lat. 29° 06′), water fresh, warm, little current. . . Early one morning . . . my brother Francis and I were casting for bass. . . . On the west side of the river there is a concentration of water plant commonly called "eel grass". Our boat was anchored in the grass. The water is about five feet deep, but tips of the eel grass are visible on the surface. . . . We had been sitting quietly. . . . Suddenly we noticed a great swirl in the water and some eel grass was thrown up on the surface. We both saw this and . . . focused . . . on this spot. Almost immediately two heads appeared close together. They submerged when they saw us, but they remained out of water long enough for us both to identify them as manatee. Many persons have reported seeing manatee at Lake Dexter . . . a few days after I saw them another person, when hearing that I had fished there, asked me if I had seen the manatee. . . ."

"April, 1950, Mud Lake, south of Lake George, St. Johns River, Volusia County, . . . This mud lake covers about 20 acres and is never over four feet deep. Near the edges the bottom is firm, but as a whole the bottom is silt covered and very soft. There is little or no vegetation on the bottom. The water is very warm

and there is always a high tannic acid content. Out near the center of the lake I noticed the movement of some large animal which . . . I approached . . . and saw it was a manatee. It was motionless in the water . . . I prodded it with an oar and noticed a slight movement in response. . . . The next day I looked for it and could not find it. . . ."

"January 5, 1950, Blue Springs, Orange City, (lat. 28° 56′) . . . water clear, cold, sulfurous, two mature, one infant observed. Observation of manatee at Blue Springs is an annual occurrence. They always appear at this time of year and are seen by hundreds of people. My father, who is 61, recalls seeing manatee at Blue Springs when he was a little boy. The owner of Blue Springs says that the manatee is capable of predicting coming cold spells because they invariably show up there two or three days before a cold snap. They are very active on the preceding warm days, but when the cold arrives they hover motionless on the bottom." Lester Leigh's remarks (letter, May 7, 1950) on the six-foot male manatee in his care at Bradenton in regard to temperature correspond interestingly to this, ". . . we keep a thermometer in the tank . . . when the [water] temperature falls below 67 degrees the manatee feed only sparingly . . . and when the temperature falls below 60 degrees [it] refuses to eat for a day or two at a time. Last summer the water temperature rose to 85 degrees and [the manatee] spent most of the time with [its] snout against the side of the tank and some eight or ten inches above the water level."

Bushnell's records conclude with, "January 15, 1951, Blue Springs. Two Stetson University students who are amateur naturalists reported to me that they had observed several manatee near Blue Springs."

In the Suwannee River at its confluence with the Santa Fe, University of Florida archaeologist John M. Goggin saw a manatee on July 6, 1949. The next year he and his wife Nanci Goggin saw a manatee on June 8th in the same place (lat. 29° 52′).

We find in the account of William Bartram (Van Doren, 1928, p. 197) a description of Manatee Spring (lat. 29° 30′) on the Suwannee River and the occurrence of the manatee in it in the 1780's. "Part of a skeleton of one which the Indians had killed last winter, lay upon the banks of the spring. . . . My companion, who was a trader in Talahasochte last winter, saw three of them at one time in this spring. . . ."

Herman Gunter, director of the Florida Geological Survey, tells me that he and E. H. Sellards saw a manatee in the Wacissa River near its mouth (lat. 30° 07′ and long. 83° 57′) in Jefferson County in about 1925.

Protection from Cold by Springs

If the manatee in the St. Johns River are stimulated to retreat south at the onset of cold weather, ones as far up river (south) as Sanford would be obliged to go north 150 miles (downstream) to the mouth of the river and from there south along the Intracoastal Waterway some 200 miles. Or they might go directly south (upstream) from Sanford as far as possible—perhaps 50 miles. However, Bushnell's above account of winter use of Blue Springs by St. Johns River manatees and Bartram's mention of winter use of Manatee Spring by Suwannee River manatees, strongly indicate that in north Florida Rivers some of these animals have found another means, and a rather unique one, of surviving severe cold. Blue Springs is easily accessible to manatees in the St. Johns River, its spring run being only 0.4 mile long and 70 to 100 feet wide (Ferguson *et al.*, 1947, p. 164). Its immense flow averages 161 cubic feet per second and provides water at 73° to 74° F. much faster than it could be chilled by the most extreme Florida freeze. Manatee Springs (Ferguson *et al*, *op. cit.* p. 107) lies 0.2 mile from the bank of the Suwannee River (lat. 29° 30′) and pours an average of 168 cubic feet of water per second into it at 72° to 73° F. The same authority (pp. 88-91) lists eight named and two un-named springs which discharge into the Wacissa River. Three of these rise in the bed of the river itself. The flow of the largest, "Big Spring," was recorded as 69.4 cubic feet per second. This flow is divided between two runs, the larger of which is described as 0.2 mile in length and 80 feet in width. Other springs which empty into these rivers could very easily have been used by manatees in primitive times and may be used to some extent even today.

Distribution in the Gulf of Mexico

After studying skeletal material, Hatt (1934, p. 538) concluded that the range of the Florida manatee was, "The coast and coastal rivers of the United States from Beaufort, North Carolina, to the Florida Keys and the coasts of the Gulf of Mexico." However,

from the coasts of the Gulf of Mexico other than that small portion which is Floridian, he examined only one specimen. This one, allegedly from Texas, he considered of doubtful origin. As long as there is a possibility that this specimen came from Florida instead of Texas as alleged, the identity of the manatee populating the shores of the Gulf of Mexico other than Florida is, of course, in doubt. Gunter (1941, p. 62) provides information regarding the origin of the alleged Texas specimen, "The Director of the Field Museum of Natural History has written me that a specimen which died in July, 1913, came to the museum from the Riverview Exposition Company of Chicago. This source told the museum authorities that the animal was from Texas. . . . This is the skull examined by Hatt. . . ." If the animal was actually taken in Florida, it seems to the present writer that the Florida law against taking them would provide ample stimulus for show people to state that the manatee came from some other logical place. For this reason it seems better to disregard the evidence provided from this specimen regarding the identity of manatee from Texas.

We have shown that Gunter (1942, p. 89) believed the Texas coast to be entirely north of the winter range of manatees of the western Gulf of Mexico, and we have assembled evidence which indicates strongly that manatees of the east coast of the Gulf of Mexico winter from the Charlotte Harbor area south. For a manatee to swim this gap across the northern coast of the Gulf of Mexico from winter range in Florida to winter range south of Texas, it must travel considerably more than a thousand miles. Under present climatic conditions it seems likely that individuals which wander into this gap from either end would very rarely reach the mid-point, and reaching there, seldom indeed reach safe latitudes again. If we may presume that no such gap lies between the Texas coast and the manatee populations of Nicaragua, Costa Rica, etc., it is logical that this gap on the northern Gulf Coast constitutes the geographic barrier which might explain the subspecies recognized by Hatt, and that the Texas animals are of the West Indian form, *Trichechus manatus manatus* Linnaeus.

Distinguishing Characters of the Subspecies

When Hatt (*op. cit.*, p. 538) reduced the manatee from the rank of species to a race of the West Indian manatee, he did not elab-

orate on the characters which he recognized as distinguishing these two forms. Indeed, there seems to be a little scepticism as to the Florida manatee meriting even subspecies rank in his remarks (p. 550) on the foramen magnum, "Florida . . . specimens of *manatus*, however, have flat dorsal rims, perhaps one of the most constant features on which the nominal race *latirostris* may lay claim to subspecific individuality from *manatus*. The notching of the lower border (the basioccipital) is also a fairly constant and peculiar mark of the northern representatives of the species *manatus*. These differences in the limits of the foramen may be partially synthesized by taking the ratio of greatest vertical diameter to greatest horizontal diameter. . . . Within the species . . . there seem to be geographic trends, for Florida specimens have indices ranging from 0.54 to 0.61; . . . while four Guatemalan manatee have corresponding indices ranging from 0.66 to 0.71; and a Puerto Rican manatee has an index of something over 0.70."

It now appears that there is further justification for the abovementioned skepticism. Henry W. Setzer, with exceeding generosity, provided me with the greatest vertical and horizontal diameters of the foramen magnum of eight manatees from one locality, Jupiter, Florida, and others from elsewhere. Table 1 shows that indices of the Jupiter series vary from 0.59 to 0.74. Interesting

TABLE I

Greatest horizontal and vertical diameters of the foramen magnum and indices of these in some manatee specimens from Florida, Texas, and Louisiana. All but the last are from specimens in the United States National Museum. William B. Davis provided the measurements from the Copano Bay, Texas, manatee skull in the collections of the Agricultural and Mechanical College of Texas.

Cat. No.	*Horiz.*	*Vert.*	*Index*	*Locality*	*Age*
1375	51.5	39.3	76.5	Brazos, Tex.	adult
228483	54.7	40.7	74.4	Jupiter, Fla.	adult
228481	56.2	39.5	70.4	Jupiter, Fla.	adult
14334	49.7	33.9	69.3	Florida	young
217259	51.4	34.1	66.4	Florida	young
228482	57.9	37.5	64.7	Jupiter, Fla.	adult
228485	63.1	40.4	64.0	Jupiter, Fla.	young
228478	60.3	38.0	63.0	Jupiter, Fla.	adult
228486	64.5	39.4	63.0	Jupiter, Fla.	adult
257406	60.5	36.1	59.7	Calcasieau, La.	adult
228479	61.4	36.4	59.4	Jupiter, Fla.	adult
228480	61.5	36.2	58.8	Jupiter, Fla.	adult
?	49.8	25.7	51.5	Copano Bay, Tex.	?

also are the indices of the two available Texas manatees, both specimens of which have been discussed previously by Gunter (1941). This leaves the relative contribution of the alasphenoid, palatine, and pterygoid bones to the pterygoid process (Hatt, *op. cit.*, p. 551) as the primary but thin basis for distinguishing between the Florida and West Indian manatees.

Summary

On the basis of reports largely of persons interested in some phase of natural history and situated on the coast or coastal rivers of Florida, and several nearby states, a contemporary distribution of the Florida manatee *Trichechus manatus latirostris* (Harlan) is presented. Ordinary coastal winter range of this animal is considered to reach northward to the Sebastian River (lat. 27° 52′) on the Florida east coast and Charlotte Harbor (lat. 26° 45′) on the Florida west coast. Ordinary coastal warm-season range is considered to extend northward on the east coast to the mouth of the St. Johns River. Exceptional east coast occurrences are cited for the Carolinas and Virginia. Exceptional occurrences on the Florida west coast are cited for the Wacissa River and the Suwannee River. Data are presented to show that any northward expansion of range in the summer of 1950 produced no apparent diminution of manatee numbers in the Everglades National Park. The gap in ordinary manatee winter range along the northern coast of the Gulf of Mexico between the Mexican border and Charlotte Harbor, Florida, is suggested as the geographic barrier explaining the subspecies *T. m. manatus* and *T. m. latirostris* recognized by Hatt (1934, p. 538). It is found that the ratio of the greatest vertical to greatest horizontal diameter of the foramen magnum does not separate *T. m. latirostris* from *T. m. manatus*. Reports are cited which indicate that some manatees evade severe low temperatures in winter in north Florida rivers by resorting to large springs and spring runs instead of migrating south.

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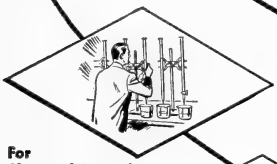

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SETTING THE PACE IN CHEMICAL PURITY SINCE 1882

HEMOCONCENTRATION IN THE ALBINO RAT DURING ACUTE HYPOTHERMIA [1]

A. C. Higginbotham and M. R. Siers

Newly-born mammals are unable to maintain a relatively constant body temperature when that of the environment fluctuates. They are, therefore, poikilothermic. Soon after birth this condition is replaced by a homoiothermic one and as a result the mammal can maintain a relatively constant body temperature even when that of the environment increases or decreases within certain limits.

This ability to maintain a relatively constant body temperature is dependent upon certain reflex physiological adjustments. Those which protect against falling temperatures include shivering, erecting the hair, increasing the tonus of skeletal muscles, increasing the rate of metabolism and altering the composition of the blood by shifting certain substances back and forth between the blood and the tissues and tissue spaces. A prominent feature of the latter is a marked shifting of water from the blood into the tissues and tissue spaces and then back again into the blood as the body temperature declines in response to severe chilling. This results first in hemoconcentration and then hemodilution. These changes are progressive and can be easily followed in dogs and other mammals of comparable size or larger. Since it was not known whether these changes in the concentration of the blood could be easily followed in small mammals, where serial blood sampling introduces the complicating factor of hemorrhage, the present study was undertaken.

Methods

For the purpose of this study, young adult albino rats aged 49-94 days were divided into control and experimental groups. Individual samples of blood were obtained by etherizing the rat and cutting off about two inches of the tail. After discarding the first one or two drops, a drop of blood was collected on a wax plate for determination of its specific gravity by the falling drop method of Barbour and Hamilton (1926). The next two or

[1] A contribution from the Department of Physiology, Florida State University.

three drops were collected in a small watch glass containing sufficient dried heparin to prevent coagulation. Following a thorough mixing of the heparinized blood, the percentages of blood cell and plasma volumes were determined by filling a micro-hematocrit tube with a portion of the sample and centrifuging for thirty minutes.

The body temperature of the rats was measured by inserting a small thermometer approximately 2 cm. into the rectum. When it was necessary to maintain a body temperature at or near normal levels, radiant heat of an electric lamp was applied.

Two control groups were tested. The first consisted of ten rats, five of each sex. These animals were kept under the influence of ether for a period of one hour during which their body temperature was maintained within 2°C. of the normal by intermittent exposure to an electric lamp. Samples of blood were obtained by the method described above approximately every 15 minutes. A second control group of three male and two female rats was tested in an attempt to discover the effects of hermorrhage on the blood of the first control group. These were treated in the same manner as the first except that only two samples of blood were collected, one immediately after the anaesthetic had taken effect and the other one hour later. In order to minimize the effect of hemorrhage, only enough blood for the specific gravity determination was collected.

The five male and five female rats in the experimental group were similar to those in the control groups and received the same pre-experimental treatment. After etherization the first sample of blood was taken and tested as in the first control group. The animal was then placed in a wire hammock suspended in an ice-water bath with the head and anal regions above the surface of the water. Meanwhile a relatively constant etherized state was maintained for about one hour by intermittent application of an ether mask. When the additional samples of blood were taken, the animal was removed from the bath and the tail again sectioned.

Attempts were made to sample the blood when the rectal temperature reached 30°, 25°, and 15°, but variations in the rate of cooling in different rats modified this sampling plan. The cooling rate between successive samplings was slow enough to allow for a gradual adjustment to the cold stimulus and not fast enough

to cause the death of the animal during the experiment. Since very little blood was present in the tail at a rectal temperature of 15°, the blood sample was obtained by quickly opening the pericardial cavity, withdrawing the blood from one of the ventricles into a dry syringe and distributing sufficient amounts of it to a watch glass containing dried heparin and a wax plate for the proper determinations. In the experimental animals, as in those of the first control group, specific gravity and hematocrit measurements were made on whole blood. When only a limited amount of tail blood was obtained, the hematocrit determination was omitted since the falling drop procedure would give a more

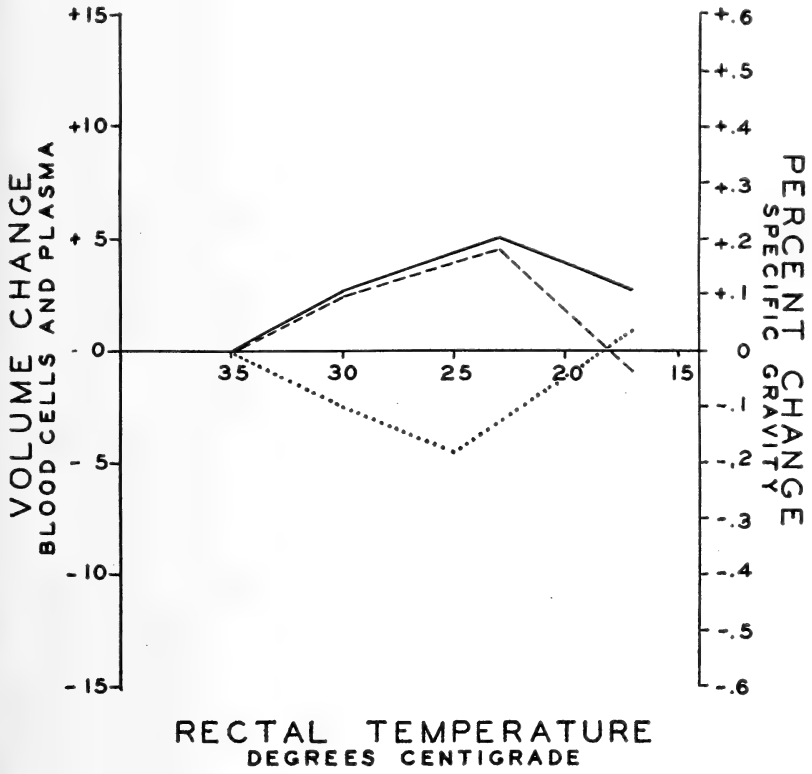

Figure 1.—The average per cent change in specific gravity (solid line) of etherized young adult albino rats with maintained body temperature compared with the average changes in cell volumn (dashes) and the average changes in plasma volume (dots).

accurate measurement of relative changes in the concentration of fluids and solids in the blood.

Results

In the etherized rats of the first control group, in which the body temperature was maintained relatively constant, hemodilution rather than hemoconcentration occurred. Hematocrit and specific gravity determination showed that the hemodilution was a consequence of reduction in plasma volume (Figure 1). Since hemodilution also occurred in the rats of the second control group where there was only a very small loss of blood (Table I), hemoconcentration does not appear to be a typical response of rats to etherization as has been found in dogs.

TABLE I

Changes in the specific gravity of the blood of etherized young adult albino rats with body temperature maintained.

Rat No.	Sex	Age Days	Weight Grams	Time Minutes	Specific Gravity	Per Cent Change Specific Gravity
1	M	94	280	0	1.0594	
				60	1.0575	–0.179
2	F	94	190	0	1.0569	
				60	1.0554	–0.141
3	M	94	284	0	1.0621	
				60	1.0605	–0.151
4	M	68	104	0	1.0509	
				60	1.0476	–0.218
5	F	68	113	0	1.0521	
				60	1.0494	–0.256

In experimental animals exposed to cold following etherization, hemoconcentration occurred first, and then as the body temperature declined further the blood became less concentrated (Figure 2). In these experiments there was a direct correlation between the specific gravity of the blood and the blood cell volume changes.

Besides observing the changes occurring in the blood, certain other responses of rats to lowered body temperature were observed. Edema of the face and jaws was noted in several of them. The degree of edema increased noticeably as the body temperature fell below 20°C. Similar observations were made by Barbour, McKay and Griffith (1943).

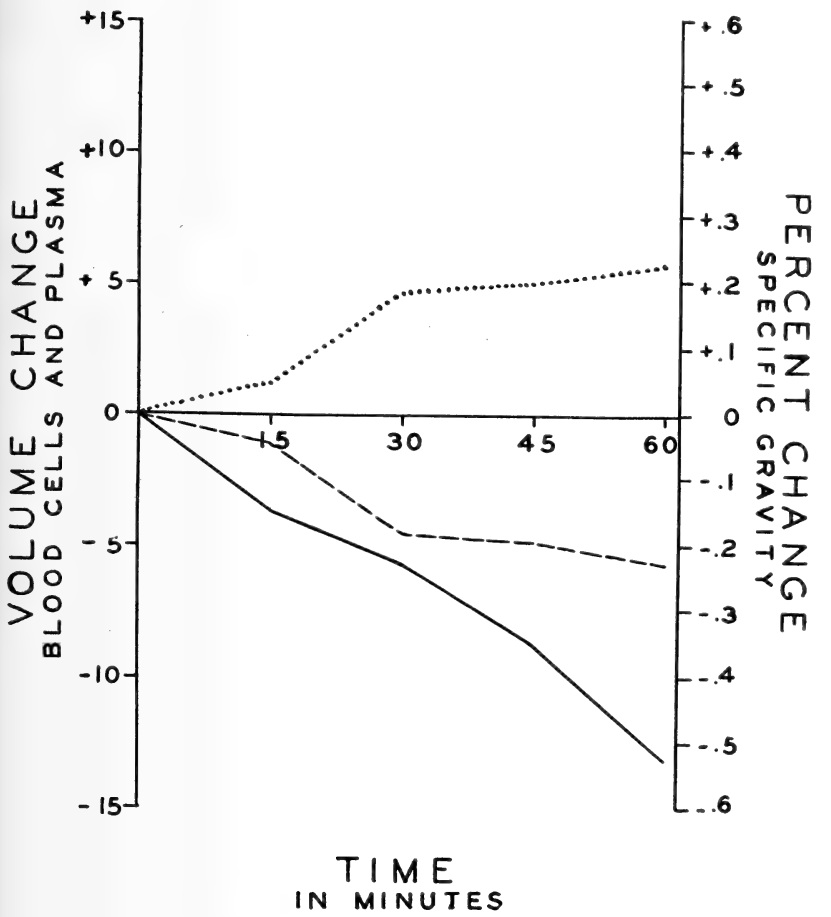

Figure 2.—The average per cent change in specific gravity (solid line) of etherized young adult albino rats exposed to cold compared with the average changes in cell volume (dashes) and average change in plasma volume (dots).

Labored breathing occurred in the control as well as the experimental animals, but in the latter, when the body temperature had fallen to 25° C. or below, breathing was slower and less laborious. At body temperatures below 25°C. ether was seldom necessary, the cold having similar anaesthetizing effects. Britton (1922) in his work on white rats and cats also found that no anaesthetic other than cold was necessary to maintain a state of anaesthesia below a body temperature of 22-24°C.

Shivering was seldom observed in the cooled rats, but peculiar convulsive movements similar to those described by Gosselin (1949) in guinea pigs were observed. These movements could often be elicited by touching the animals.

Discussion and Conclusions

The data obtained in this study demonstrate that white rats respond to severe chilling as do dogs (Ederstrom and DeBoer, 1947) by concentrating their blood as their body temperature declines and then, as the temperature regulating reflexes begin to fail, diluting their blood. According to Barbour and Hamilton (1925), the hemoconcentration is the consequence of water escaping from the capillaries into the tissue cells or spaces at a faster rate than that at which it enters. They believed that the cold acted directly on the arterioles, or nerves leading to them, thus causing constriction of the arterioles and slowing of the blood flow with resultant anoxemia and capillary relaxation.

The suggestion that the initial effect of cold on homoiothermic animals might cause increased cellular activity, involving more extensive oxidations and the breakdown of metabolites which would necessitate the entrance of more fluid into the cells at the ultimate expense of the blood plasma, was strengthened subsequently by the findings of Barbour and his co-workers when they found a marked increase in the metabolic rate of rats cooled to body temperatures of 26-30°C.

The hemodilution which always followed the initial response of hemoconcentration as the body temperature fell toward lethal levels appeared to be a consequence of several factors. Since the heart slowed markedly as the body temperature fell to low levels, it seemed the resulting low blood pressure was insufficient to maintain the filtration pressure within the capillaries and fluid re-entered the circulation from the cells and intercellular spaces. The re-entrance of fluid into the circulation could have been augmented also by the lowered osmotic pressure of tissue cells as a consequence of the marked decrease in metabolic rate which Barbour and co-workers demonstrated to occur in rats cooled below 20°C.

Findings of other investigators suggest that processes involved in the hemoconcentration response of dogs may be similar to

those producing this response by the administration of ether. Since the control animals used in this study did not respond consistently by concentrating their blood when given ether, albino rats apparently do not respond in exactly the same manner. It may be that the processes in rats and dogs are similar but differ in the degree they are brought into play.

Irrespective of their apparent difference in response to ether administration, both rats and dogs concentrate and then dilute their blood as their body temperature falls from normal to 15°C. or lower.

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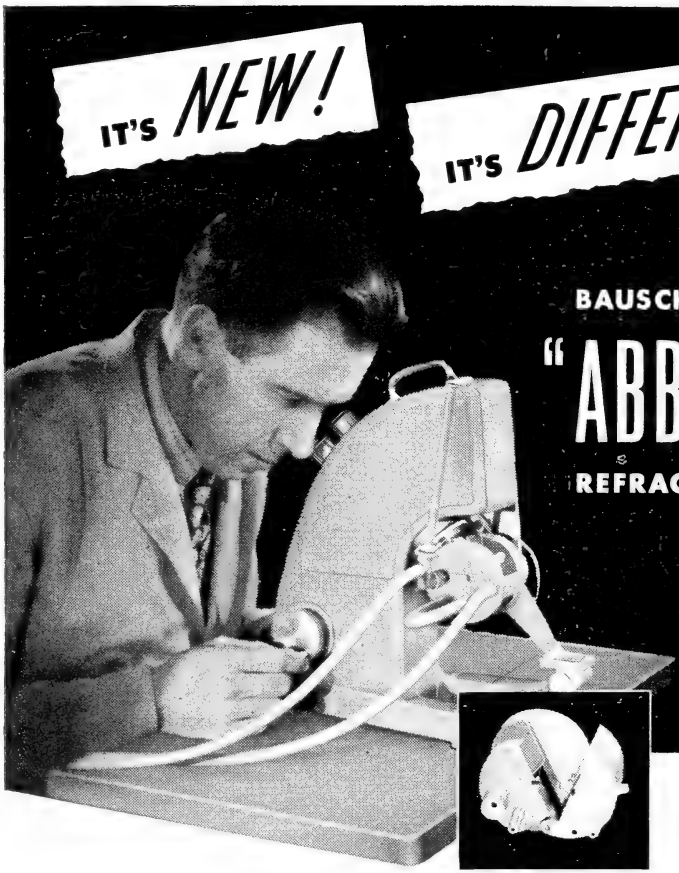

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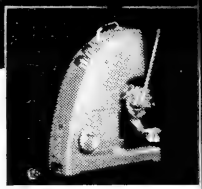

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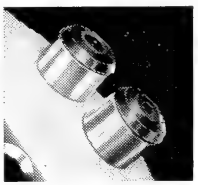

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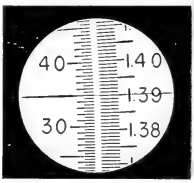

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NOTES ON THE NATURAL HISTORY OF THE LIZARD *EUMECES LATICEPS*, IN NORTHERN FLORIDA

Olive B. Goin and Coleman J. Goin

University of Florida

The following notes have accumulated over several years from nearly daily observations of a small population of *Eumeces laticeps* (Schneider) in our back yard near Gainesville, Alachua County, Florida.

The study area is a plot about a quarter of an acre in extent on the border of a typical North Florida hammock. The most conspicuous and abundant trees are water oaks *(Quercus niger)*. In addition there are several small black gums, sweet gums, hickories, blue beeches *(Carpinus)*, and a few other hammock trees such as one holly and two small magnolias. Much of the underbrush has been cleared out but the leaf mold has for the most part been left undisturbed.

In this restricted area, at least, large holes in the bases of the water oaks are the sites occupied by *laticeps*, as places not only of nocturnal abode but also for hibernation. This is somewhat at variance with the observations of other authors who have reported mainly dead pine stumps as the modal niche for hibernating *laticeps* (Carr, 1940: 76; Neill, 1948: 110). In the period of activity during the day, the lizards sometimes range away from the trees in which their hollows are located, but our observations indicate that when they do so they return to them to retire for the day.

There seems to be a quite definite period of hibernation. The earliest records of emergence for 1948, 1949, and 1950 are respectively April 7, March 26, and March 27. Appearance in the spring seems to be correlated with temperature, the first emergence ocurring only after the air temperature has reached a maximum of 80° or above for several consecutive days. In 1948 there were six such days, three in 1949, and three in 1950. The minimum temperatures of the nights prior to emergence were 67° in 1949 and 61° in 1950. Once they have become active in the spring, however, the lizards tend to appear on any warm day, since in 1950 one was seen on April 17 although there had been

frost, with a minimum temperature reading of 34°, on the morning of the 16th. Also, once they have emerged from hibernation, they may appear at temperatures below 80°. Thus, the one seen on April 17, 1950, was out at 3:00 in the afternoon when the temperature was 76° although it had been 78° earlier in the day. The highest temperature at which a *Eumeces* has been seen is 98°. (All temperature readings were made on a maximum-minimum thermometer fastened out of the direct sunlight on the north side of one of the hollow oaks known to be inhabited by *Eumeces*.)

Adult *Eumeces* hibernate earlier in the fall than the young do. In 1949 the last adult of the year was seen on September 29 while the juveniles remained active until October 10. The following year the last adult was recorded on September 22 and the last juvenile again on October 10. There does not seem to be any correlation between air temperature and the onset of hibernation. In 1949 the temperature was 80° or above during the day for three weeks, and did not drop below 60° at night for ten days, following the disappearance of the skinks. In 1950 no *Eumeces* were seen during a warm rainy spell between October 3 and 9, but one was seen the following day although there had been a drop in temperature from a low of 70° on the morning of the 9th to a low of 57° on the morning of the 10th.

When the lizards first emerge from hibernation in the spring they are most frequently seen around noon or in the afternoon. For over a month after their appearance in 1950 none were seen before 10:30 in the morning and only two before 11:00. On April 30 one was recorded at 9:55 and on May 7 at 9:15. For the first month or six weeks the *Eumeces* are apparently actively feeding and individuals may remain out for periods of several hours. One seen on March 27, 1950, was out most of the afternoon from 2:45 until 5:00. Later in the season they come out only briefly and usually not more than one or two are seen on any one day, frequently none, whereas earlier three or four may be out at one time. Most of our records during June, July, and August are for the late morning or early afternoon.

Hibernation is preceded by another period of increased activity, beginning about the middle of September. The lizards come out earlier and earlier in the morning, at lower and lower temperatures. For the first week of this active period in 1949, 78° seemed

to be the critical temperature, but on September 19 two young were seen at 8:05 when the temperature was 75° and two days later an adult was out at 7:55, temperature 74°. In 1950 one was seen at 8:30 on the morning of September 21 when the temperature was 72°. They also remain out for longer periods of time. The adult seen at 7:55 on the morning of September 21, 1949, was there continually until 3:15. They have been recorded at this time of year on overcast days when there was little sun and even when a light drizzling rain was beginning to fall.

A curious thing was noted in August, 1950. The month had been unusually warm and dry, weather like that ordinarily expected in early September, and no *Eumeces* were seen between the 12th and the 24th. Then for a few days there was a period of activity on the part of the lizards such as normally occurs in the last half of September. The last few days of the month the weather was more like that usually occurring early in August, with rain in the afternoons, and the *Eumeces* returned to the pattern of activity normal for the summer and did not become markedly active again until the last third of September.

The lizards seem to be much less active during periods of drought, but no direct correlation between activity and humidity has been noted. Relative humidities recorded at times when the lizards were out range from approximately 40, which is as low a reading as has been made by us for the hammock during the summer months, to 100 when, as noted above, a drizzling rain was falling.

The population was at a very high level during the late summer of 1949. One adult and one young were living on each of four hollow water oaks in an area of about an eighth of an acre in the back yard and others inhabited trees at the side and front of the house. During the period of activity in late September two large ones or two small ones were never seen together on any of these four trees, but frequently an adult and a young were seen at the same time on the same tree. There was never any sign of aggressive activity by the larger *Eumeces* towards the smaller ones. A sharp reduction in the population of adults was noted in 1950, although during the spring the yearlings seemed to be more numerous than they had been the year before. In the pre-hibernation period of activity in September, 1950, only one of the four

trees mentioned above was inhabited by an adult although each tree again had one young living in it.

In this region hatching apparently takes place late in June or early in July. In 1950 the first young of the year, a very small one, was seen on July 2. A number of other young were seen in the next few weeks. One which was measured on July 13 had a head and body length of 35 mm and a total length of 85 mm.

Most of the feeding activity which has been observed by us took place in April and the first part of May. *Eumeces* have been seen eating cockroaches, spiders, and ants. Once a young one was seen to be carrying a small green caterpillar in its mouth, but this was later abandoned.

On several different occasions it was noticed that the lizards did not gulp their prey down immediately but spent some time toying with it first. A young *Eumeces* was once seen on the woodpile under one of the hollow water oaks with a spider about one inch long which it was holding in its mouth by the cephalothorax. It played with the spider rather as a cat plays with a mouse, shook it and threw it, then grasped it again. Once the spider fell from the woodpile and the lizard ran down to the ground, picked it up and carried it back up to the top of the woodpile.

Another time a young *Eumeces* on the woodpile had a large cockroach. As the lizard shook it, part of it fell to the ground. The *Eumeces* ran down the woodpile to the ground, retrieved the piece, and climbed back on the woodpile. This segment was part of the thorax and abdomen with one leg still attached. When it was all in the mouth except the leg, the lizard shook its head and seemed to be trying to scrape the leg off against the wood but was unable to do so and finally swallowed it. The wings and at least one leg were not eaten.

While the yard was being watered on May 6, 1950, during a very dry spell when there had been no rain in the daytime for about a month, spray from the hose fell on one of the hollow trees in the front yard and a *Eumeces* immediately came out and started lapping up the drops of water on the bark. Several other trees were then sprayed and on three of them *Eumeces* came out and lapped up water within just a few moments' time. On May 21, with conditions of drought still prevailing, a *Eumeces* was

seen at the edge of the small pool in the back yard, apparently drinking from the pool.

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A MODIFIED SEMI-MICRO KJELDAHL NITROGEN ANALYTICAL PROCEDURE

Jackson P. Sickels and Harry P. Schultz

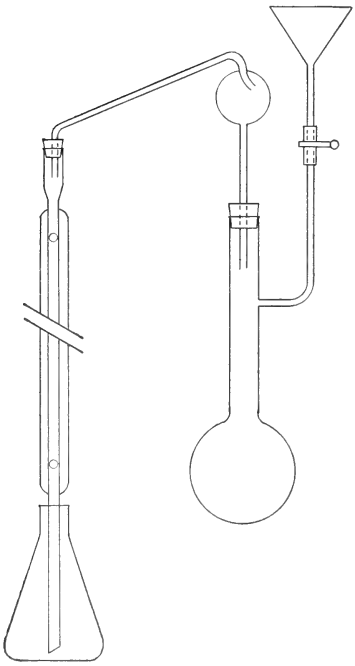
Chemistry Department, University of Miami

Despite the numerous Kjeldahl nitrogen analytical procedures published in the literature, some degree of skill is necessary to obtain accurate and reproducible results. This is particularly true of research workers in organic chemistry who find it advantageous to use a semi-micro procedure and who use it only intermittently. A procedure has been developed in this laboratory which uses the minimum of equipment and standard solutions, is convenient and easy to use, and which gives good results in the hands of students who have had no previous experience with semi-micro Kjeldahl determinations.

The procedure is a combination of previously known analytical methods which provides a noteworthy ease and convenience of operation. The design of the digestion flask may perhaps be new. This is prepared by bending the side arm of a 125 ml. distilling flask up parallel with the neck. Sodium hydroxide solution is added through a short-stem funnel attached by a rubber connection to this side arm. The rate of addition is controlled by a screw clamp which is closed to prevent loss of ammonia, after the base has been added. The digestion flask is thus also used for the distillation. It can easily be made from ordinary laboratory apparatus. The design is shown in a figure.

The ammonia is absorbed in 2% boric acid solution.[1] This eliminates the use of standard sodium hydroxide solution, thereby decreasing the quantitative operations, since the boric acid solution need not be accurately prepared or measured out. It is also very convenient for intermittent use since standard sodium hydroxide solution does not keep well.

The use of a mixed indicator is an improvement over the use of methyl red alone. Bromcresol green-methyl red[2] has been found to be an excellent mixed indicator for the boric acid method. It gives a very sharp endpoint, adequate forewarning, and the first appearance of pink color is the endpoint. Thus it does not require matching to a color standard as is the case with some



indicators used with the boric acid method.

In the above procedure no standard base is prepared. Thus the usual indirect method of standardization cannot be used. A convenient method of standardizing the hydrochloric acid solution directly is to use diphenylguanidine.[3]

Typical analytical results on pure nitrogen compounds are shown in the table below. Most of these results were obtained by M. S. candidates in the course of their research work. Of the compounds so far tested in this laboratory, only one, 6-nitroquinoxaline, has failed to give satisfactory results. It can be presumed that in this case the digestion failed to liberate all of the nitrogen.

TABLE I

Compound	% N, Calc.	% N, Found	Observer
5-Nitroquinoxaline	24.0	23.9, 23.9	Harry P. Schultz
2-Hydroxy-3-methyl-6-methoxy-quinoxaline	14.7	14.8, 14.7	Seymour Yolles
7-Octen-4-one oxime	9.9	9.8, 9.9	Bernard Herman
1-Nonene-5-one oxime	9.0	9.0, 8.9	Bernard Herman
1-Propyl-4-pentenylamine	11.0	10.9, 10.9	Bernard Herman
1-Phenyl-2-nitropropene-1	8.6	8.5, 8.6	Bill Clark
Acetanilide	10.4	10.4, 10.3	Bill Clark

Experimental Section

Into a 125 ml. round-bottom distilling flask (modified by having had its side arm bent up parallel with the neck—see figure) is placed 20-40 mg. of purified dried sample, weighed on an ordinary analytical balance and wrapped in a two-inch square of aluminum foil 0.001 inch thick, 1 g. of anhydrous potassium sulfate, and 0.25 g. of dextrose. Nitrogen-free sulfuric acid, 6 ml., and one selenized Hengar granule [4] are then added, and the contents of

the flask are refluxed vigorously for four hours.[5] While digestion is proceeding, the distillation assembly is steamed out and 35 ml. of 2% boric acid solution in distilled water [6] is prepared in a 250 ml. Erlenmeyer flask. The digestion flask is cooled, the contents are diluted with 20 ml. of water, and 0.5 g. of zinc granules is added. After the digestion flask has been connected to the distillation assembly, 20 ml. of carbonate-free 50% sodium hydroxide solution is added slowly, followed by 20 ml. of distilled water, through the addition funnel. The screw clamp is closed before the last of this water enters, to prevent loss of ammonia through the side tube. The basic solution in the flask is slowly distilled into the receiver containing the boric acid solution until 30-40 ml. of distillate has been collected. Three drops of bromcresol green-methyl red mixed indicator solution [2] is added to the distillate, which turns green if it contains ammonia. The ammonia held in the boric acid solution is then titrated directly with 0.02-0.05 N hydrochloric acid solution, accurately standardized, to the first faint pink color as an end point. The green color fades to grey then to colorless before the pink appears. It is convenient to standardize the hydrochloric acid solution against diphenylguanidine according to the procedure of Carlton [3] using the bromcresol green-methyl red mixed indicator.

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[1] E. C. Wagner, Ind. and Eng. Chem., Anal. Ed., **12**, 771(1940); E. W. Meeker and E. C. Wagner, *ibid.* **5**, 396 (1933). These authors use 4% boric acid solution.

[2] Three parts of 0.1% bromcresol green in alcohol; one part of 0.2% methyl red in alcohol. Acid color is wine-red; alkaline, green. I. M. Kolthoff, transl. by C. Rosenblum, *Acid-base Indicators*, New York, Macmillan, 1937, p. 178.

[3] C. A. Carlton, J. Am. Chem. Soc., **44**, 1469 (1922).

[4] Hengar Company, Philadelphia, Pennsylvania.

[5] This is the maximum time necessary for digesting heterocyclic compounds. Most nitrogen compounds can be digested in one to two hours.

[6] This must be prepared fresh each time. Crystalline boric acid dissolves more readily than the powder.

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FLUORESCENCE STUDIES OF METHYLCHOLANTHRENE IN THE MONKEY SKIN [1]

PERIHAN CAMBEL

Simpson and Cramer (1943a) showed fluorohistologically that 20-methylcholanthrene (MC), a carcinogen that easily induces epidermal carcinogenesis in mice after skin painting, first entered the sebaceous glands in the skin. From here, the carcinogen penetrated into the epidermis and the subcutaneous fat tissue. The role of the sebaceous glands in epidermal carcinogenesis was pointed out and discussed by Lacassagne and Latarjet (1946), by Suntzeff, Carruthers and Cowdry (1947), by Simpson and Cramer (1943a, 1943b), and Simpson *et al.* (1945). Fluorescence microscopic studies with MC were made by Cambel (1951) in the skin of the rat, an animal relatively resistant to epidermal carcinogenesis according to Bachmann *et al.* (1937), and Bereblum (1949). These studies showed a difference in the pathway of this carcinogen after absorption following skin painting. MC easily entered the sebaceous glands, but did not penetrate the epidermal cell layers nor the subcutaneous fat tissue, except for a few droplets seen occasionally adjacent to a sebaceous gland. Therefore, the existence of two physiological barriers in the skin of rats, protecting this species against the carcinogenic action of MC, was postulated by the present author.

Pfeiffer and Allen (1948) observed that the monkey showed definite resistance to the action of MC administered by skin painting over long periods. A fluorohistological study seemed indicated to investigate the possible existence of similar protective barriers against the induction of skin carcinoma in this species.

The work was carried out in 2 male and 2 female Rhesus monkeys and one male Java monkey. Their ages varied from one year and a half to ten years. MC in a 0.6 per cent benzene solution was painted with a camel hair brush No. 4 on a limited area of the previously shaved interscapular skin of the animals during nembutal anesthesia. Three of the five animals had been chordotomized for a neurophysiological experiment. Samples of the

[1] A Contribution from the Cancer Research Division, Department of Anatomy, Washington University, School of Medicine, and Cancer Research Laboratory, University of Florida.

painted and unpainted interscapular skin were taken from 15-30 minutes after painting, and prepared for fluorescence studies as previously described (Cambel, 1951).

In the unpainted samples the normal autofluorescence of the sebaceous glands was observed. This seemed dimmer than that of albino rats. Due to pigmentation, naturally, no marked autofluorescence could be noted in epidermis and hairs, thus contrasting strongly with albino animals.

In the painted samples the typical blue-violet fluorescence of the MC was seen in the cells of the sebaceous glands (Fig. 1). This fluorescence was also dimmer than that of the same carcinogen in the sebaceous glands of the rat. Occasionally, one or two small blue-violet droplets were seen in the corium adjacent to a sebaceous gland. No penetration of the fluorescent carcinogen into the cells of the surrounding epidermis or the subcutaneous fat tissues was ever observed. However, evidence of a slight fluorescence was seen in the corium in the photomicrograph of one of the monkeys. As observed in the mouse and the rat, the nuclei of the sebaceous gland cells were optically empty.

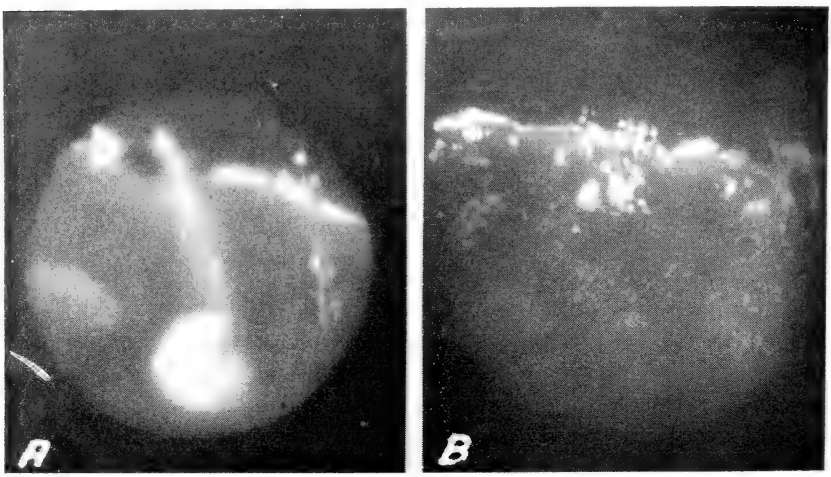

Figure 1.—"A" Fluorescence photomicrograph of sebaceous gland in MC-painted skin of female Rhesus monkey No. 1. Keratin layer shows partly MC fluorescence. Magnification 176x. "B" Fluorescence photomicrograph of MC-painted skin of female Rhesus monkey No. 1. Fluorescence imparted to sebaceous glands and the keratin layer of the epidermis by the carcinogen. A few droplets of the compound are seen adjacent to the glands and their excretory ducts and others lying above the skin surface. Magnification 40x.

These findings suggest a similarity between the skin response of the monkey and the rat toward MC in a benzene solution, which differs from that of the MC-susceptible mouse skin. Evidence suggests that the sensitization of the epidermis by direct contact with the carcinogen is a condition necessary for the induction of epidermal carcinogenesis according to Simpson and Cramer, (1943a, 1943b), Lacassagne and Latarjet (1946), and Cambel (1951). The occurrence of direct contact is evidenced in the mouse by the blue-violet fluorescence of MC in the epidermis (Simpson and Cramer (1943a), Lacassagne and Latarjet (1946). This evidence is lacking in the monkey and in the rat, two species which are resistant and relatively resistant to the carcinogenicity of this compound. Therefore, the existence of a sebaceous gland-epidermis barrier is suggested in these two species. The existence of this barrier probably prevented the penetration and sensitization of the epidermis of monkeys by MC in Pfeiffer's and Allen's experiments.

The significance of the sebaceous gland-subcutaneous fat barrier toward MC in the monkey as well as the rat remains to be elucidated.

Acknowledgments

These investigations were made possible by grants from the American Cancer Society, Inc., and the Damon Runyon Fund. Thanks are due to Dr. F. Morin, (Department of Neurophysiology, Washington University, St. Louis, Mo.), for making the monkeys available for our studies.

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X-RAY LINE BREADTH CORRECTIONS [1]

J. Whitman and K. L. Yudowitch

Florida State University

This investigation was undertaken to determine which of the proposed instrumental corrections should be used for the calculation of crystallite size by means of X-ray line broadening. The application of the familiar Scherrer equation,

$$L = \frac{k \lambda}{\beta \cos \theta} \tag{1}$$

where:

L = crystallite size
k = a constant
λ = X-ray wave length
β = line breadth due to crystallite size
θ = Bragg angle,

is usually complicated by the width of the diffraction line from sources other than crystallite size. The two major causes of line broadening in addition to crystallite size are the unresolved K α doublet and the camera geometry. Jones (1938) has given a method of correcting the observed line breadth for the effect of the K α doublet.

Jones (1938) and Warren (1941) have discussed the instrumental correction. The results obtained from the application of these two forms of the correction are not generally in agreement. This disagreement was the occasion of a brief discussion at the 1949 summer meeting of the late American Society for X-Ray and Electron Diffraction, instigating this investigation.

It is evident that the instrumental correction may be significant for a suitable choice of crystallite size, X-ray wave length and Bragg angle; negligible for another choice of these parameters. For a selected sample, the relative significance of the instrumental correction is controlled by the choice of wave lengths. Molybdenum and Chromium K α radiation were selected as the most convenient, widely divergent wave lengths. Patterns of a standard ZnO sample were taken with a convenient geometry as devised

[1] This paper is based on work sponsored in part by the Biological Dept., Chemical Corps, Camp Detrick, Frederick, Md., under Contract No. W-18-064-CM-229 with the Florida State Univ.

by Yudowitch (1949b) to ascertain the instrumental breadth. A simple calculation then revealed that a crystallite size of 100-150 A.U. would yield line broadening with Molybdenum radiation of an amount comparable with the instrumental broadening. This same crystallite size would yield sufficient broadening with Chromium radiation to make the instrumental broadening relatively insignificant. In accordance with these computations a uniform colloidal gold of this size was prepared by a method described by Yudowitch (1949a).

Patterns of the colloidal gold were taken with Mo and Cr radiation. The prominent (111) lines were densitometered. Patterns were also taken of ZnO under identical conditions. ZnO lines adjacent to the (111) gold lines were densitometered as standards.

Table I lists the Bragg angles (θ) for the gold lines, the observed integral breadths (B_0) of these lines and the observed integral breadths (b_0) of the standard ZnO lines. From the computed α-doublet separation (d), the α-doublet corrected values (B) and (b) are graphically determined as outlined by Jones. All breadths reported are integral line breadths.

If the value (B), corrected for the α-doublet broadening only, is now used for the broadening (β) in Equation (1), the result would be in error by the amount of instrumental broadening (b). This error is seen from Table I to be quite significant for the Mo pattern, but relatively minor for the Cr pattern. The resultant crystallite sizes are 35K A.U. and 90k A.U., respectively. The true value is then slightly greater than 90k A.U., the Cr value.

TABLE I

Line Breadth Data

λ	θ	B_0	b_0	d	B	b
Mo	8°40′	.0207	.0129	.00092	.0206	.0128
Cr	29°9′	.0293	.00712	.00189	.0291	.00659

The Warren correction for the instrumental breadth is made by application of the following formula:

$$\beta = (B^2 - b^2)^{1/2}. \qquad (2)$$

This relation yields a corrected value $B = 0.0162$ radians for the

Mo broadening. This β in Equation (1) in turn yields a crystallite size L = 44k A.U.

The Jones correction for instrumental breadth is made graphically from Figure 3 of Jones (1938) for B/B vs. b/B. This yields a value $B = 0.0100$ radians for the Mo broadening. The corresponding crystallite size is L = 72k A.U. These results are arranged in Table 2.

TABLE II

Resultant Crystallite Sizes

correction	λ	β	L
uncorrected	Mo	.0206	35k
Warren	Mo	.0162	44k
Jones	Mo	.0100	72k
uncorrected	Cr	.0291	90k

As stated above, the uncorrected Cr value of the crystallite size is only slightly below the true value. It is immediately obvious then from Table 2 that, for data where the instrumental breadth correction is significant, the Jones method is to be preferred to the Warren method of correction.

An independent measurement of the same specimen by the Guinier (1939) method of small angle X-ray scattering yields a particle size of 132 A.U. If it were assumed that the colloidal gold specimen consists of single crystals, this particle size should be in agreement with the crystallite size from line broadening. If we take von Laue's (1926) value for k = 1.42, our line broadening value from the uncorrected Cr pattern becomes L = 128 A.U. This agreement suggests that the value 1.42 for k may be preferred over other smaller values proposed by Scherrer (1918) and Seljakow (1925).

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NEWS AND COMMENTS

The Council Meeting at the University of Tampa on April 7, 1951, was attended by T. R. Alexander (President), H. H. Sheldon, J. E. Hawkins, A. C. Higginbotham, S. deR. Diettrich, A. M. Winchester, R. S. Bly, K. Yudowitch, C. T. Reed, A. H. Denyes, L. I. Williams, G. G. Becknell, G. F. Weber, and the Editor. Items of interest to the membership are extracted from the minutes and given below:

"The Secretary-Treasurer reported an anticipated deficit of a sizable nature. After considerable discussion the Council came up with a plan to enable us to continue to publish the Quarterly and still come out of the red within a year or a year and a half. This plan involved cutting the size of Volume 14 of the Quarterly to 240 pages, approximately 120 pages of which would be taken up with a paper on the Compositae of Florida, and for which the Academy would receive a generous sum from the University of Miami to help defray the costs of publication."

"Announcement was made that the A. A. A. S. had advised us that we now have $73.50 available for the support of research this year."

"The Council voted to hold the meetings in Tampa on November 30 and December 1. It was agreed that a general session should be scheduled for the evening of the 29th. The complete schedule will be as follows:

General Session and Council Meeting	Thursday evening
Sectional Meetings	Friday morning
Sectional Meetings	Friday 1:30 - 3:00 P.M.
General Session	Friday 3:15 - 4:30 P.M.
Dinner	Friday 8:00 P.M.
General Session	Saturday 8:30 - 9:30 A.M.
Business Meeting	Saturday 9:30 - 11:00 A.M.
Sectional Meetings	Saturday 11:15 A.M. - 1:00 P.M.

"The first call for papers will be sent out around the 1st of June by the section chairmen; second call around October 1; the *deadline* is October 31."

"The Council voted to discontinue the Annual Award."

"The Council approved the proposition of raising the annual dues to $5.00. This will require notification of the membership

in advance and an affirmative vote of the membership at the annual meeting. The By-Laws Committee will be asked to re-write the by-laws so that our regular membership be increased to $5.00, and the contributing membership to $7.50. The other categories will remain unchanged."

Someone has suggested (I wonder whom?) a painless way of raising one's membership category in the Florida Academy; without it costing an additional penny! Simply go over your present list of subscriptions and memberships and if you find one that you would never miss anyhow just cancel and transfer the funds to the Florida Academy.

F. S. U. is the proud possessor of an electron microscope. Dr. Yudowitch (Physics) explained its "Operation and Potentialities" to the Sigma Xi Club at Tallahassee on April 18th. We hear Miami is in the market.

By the time this number reaches the consumer it will probably be too late in the season to do anyone any good, but anyhow, F. S. U. has some Graduate Assistantships in Physics available paying $100.00 per month.

Staff members of the Department of Biology at the University of Florida are planning to take advantage of the new Summer School-Vacation plan in a big way. Dr. E. Lowe Pierce will spend most of the summer at the Scripps Oceanographic Institute at La Jolla, California. The Quarterly Journal editor will travel to Michigan to make a survey of the spiders of the E. S. George Reserve, near Ann Arbor—a University of Michigan property. Dr. Frank N. Young, ex-editor, now at the University of Indiana, will join him there. Dr. Archie F. Carr, Jr., is off to Jamaica for three weeks and then on to Mexico. Dr. C. J. Goin will spend part of the summer at the Mountain Lake Biological Station. Dr. H. B. Sherman will teach mammology at the Rocky Mountain Biological Laboratory near Crested Butte, Colorado. Dr. C. F. Byers will teach invertebrate zoology at Put-in-Bay, Ohio.

Dr. W. C. Allee, Head Professor of Biology at the University of Florida, was recently elected to membership in the National Academy of Sciences.

Florida institutions were well represented at the Tuscaloosa meeting of the Association of Southeastern Biologists in April. The meeting was a good one. A number of interesting papers

were presented. This is an active organization and deserves the support of all Florida biologists.

Dr. Arnold B. Grobman (Biology, U. of F.) now has a "hard-backed" book to his credit. The U. of F. Press has recently released his "Our Atomic Heritage".

Dr. A. M. Winchester (Biology, Stetson) is the author of a new book intended for use in college genetics courses. Titled "Genetics", it is published by John Wiley and Sons.

The Secretary-Treasurer, Dr. A. C. Higginbotham (Physiology, F. S. U.), will spend part of the summer at the St. Louis School of Medicine doing research.

This number is quite late in making its appearance, due in part at least, to the fact that we were in the process of changing printers. The next number should follow close on the heels of this one. There should be lots of interesting news items concerning the summer activities of the membership. Please send these in immediately to the Associate Editor, Dr. J. C. Dickinson, Jr. (Biology, U. of F.).

Research Notes

A NOTE ON THE FOOD HABITS OF CAPTIVE SHREWS, *CRYPTOTIS FLORIDANA*.—One aggravating handicap to the successful maintenance of Florida short-tailed shrews, *Cryptotis floridana* (Merriam), in the laboratory had been the large amount of time necessary to provide them with sufficient

Date	Supplementary Foods	Weight of Shrews in Grams	
		Female	Male
March 7, 1949	20 earthworms	4.5	
March 12, 1949		5.2	
March 14, 1949	1 grasshopper, *Shistocerca americana* 25 earthworms 3 ants, *Odontomachus* sp.		4.6
March 21, 1949	1 chameleon, *Anolis carolinensis* 1 frog, *Acris* sp. 1 roach, *Eurycotis floridana*	5.6	4.2
March 23, 1949	1 skink, *Leiolopisma unicolor* 1 pine lizard, *Sceloporus undulatus* 4 mole crickets, *Gryllotalpa* sp.		
March 28, 1949		5.2	5.2
April 26, 1949	1 chameleon, *Anolis carolinensis*		

food. The following data obtained on two shrews in the laboratory suggests a way to avoid this difficulty.

A female shrew was placed in a vivarium on March 4, 1949, and a male was added eight days later. Data on food habits and weights of the shrews were recorded until April 26, 1949. These shrews were given commercial dog chow pellets as a basic laboratory diet, but they did not eat them in the dry form. The shrews did, however, eat moist pellets that had been dipped hastily in water, and these served as the sole diet for the shrews for as long as 29 days.

Several supplementary foods were supplied over and above the basic diet, as shown in the accompanying table. In all cases, the living animal material was eaten on the day it was offered and none was stored for future use.

In killing the vertebrates listed in the table above, the shrews dodged from side to side, dashing in and nipping the prey and then hurriedly retreating. When the *Anolis* was placed in the vivarium at 9:32 A.M. on April 26th, the two shrews cooperated to kill it. One shrew nipped at the lizard's face and head while the other shrew bit the tail again and again. Four minutes later the *Anolis* appeared to be paralyzed, for it moved its limbs only very slowly and awkwardly and its breathing appeared exceptionally heavy. After resting for several minutes the shrews began to eat the lizard, one starting on the head and one on the tail. These shrews refused a toad, *Bufo terrestris*, a lepidopterous larva, and a diplopod.—PAUL G. PEARSON, Department of Biology, University of Florida.

FLORIDA ACADEMY OF SCIENCES

Contributions to the JOURNAL may be in any of the fields of the sciences, by any member of the Academy. Contributions from non-members may be accepted by the Editors when the scope of the paper or the nature of the contents warrants acceptance in their opinion. Acceptance of papers will be determined by the amount and character of new information and the form in which it is presented. Articles must not duplicate, in any substantial way, material that is published elsewhere. Articles of excessive length, and those containing tabular material and/or engravings will be published only with the financial cooperation of the author. Manuscripts are examined by members of the Editorial Board or other competent critics.

MANUSCRIPT FORM.—(1) Typewrite material, using one side of paper only; (2) double space all material and leave liberal margins; (3) use 8½ x 11 inch paper of standard weight (avoid onion skin); (4) do not submit carbon copies; (5) place tables on separate pages; (6) footnotes should be avoided whenever possible; (7) titles should be short; (8) for bibliographic style, note closely the practices employed in Vol. 11, No. 4 and later issues; (9) a factual summary is recommended for longer papers.

ILLUSTRATIONS.—Photographs should be glossy prints of good contrast. Make line drawings with India ink; plan linework and lettering for at least one-half reduction. Do not use typewritten labels on the face of the drawings; provide typed legends on separate sheets.

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THE COMPOSITAE OF SOUTH FLORIDA

R. Bruce Ledin

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THE QUARTERLY JOURNAL OF THE FLORIDA ACADEMY OF SCIENCES

VOL. 14 JUNE-SEPTEMBER, 1951 NOS. 2-3

THE COMPOSITAE OF SOUTH FLORIDA[1]

R. BRUCE LEDIN

University of Miami

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The purpose of this report is threefold: (1) To describe the species of composites in this area and to present a workable key to these species based mainly on vegetative characteristics. This is important because manuals of floras covering a larger area often contain so many species that it is difficult for the beginner to use the keys and to make certain what the species are. (2) To determine what species are "tropical" and if possible to correlate our flora with that of the West Indies. (3) To make a contribution to the study of the flora of South Florida.

The area covered in this report includes all of Dade County and Monroe County (including the Sand Keys off Key West), and most of Broward and Collier Counties. This area is part of what is called "subtropical" United States and includes the recently established Everglades National Park.

All of the leaves were drawn to scale twice life size and have been reduced in a ratio of approximately 9 to 4.

[1] This paper is published with the aid of a grant from the University of Miami.

DEC 6 - 1951

The author wishes to express his appreciation to the many people who helped in the preparation of this work: Dr. Jay F. W. Pearson, Vice President of the University of Miami; Dr. Taylor R. Alexander, Chairman of the Botany Department, University of Miami; Dr. Walter M. Buswell, Curator of the Buswell Herbarium, University of Miami; Dr. Robert Hanks, Florida State University; Mr. Roy Woodbury and Dr. Floyd Shuttleworth of the Botany Department of the University of Miami; Curtis Jackson, Larry Isham, and Marion Cox, former students in Botany at the University of Miami; Ardys Magner who made the drawings; Jack Grant, and Carl Sile of Miami; and Dr. H. M. Moldenke of the New York Botanical Garden, New York City, who supplied herbarium specimens.

CHARACTERISTICS OF THE FAMILY

The family *Compositae* is not only the most highly developed of flowering plants but also the largest family — the number of species estimated at from 15,000 to 20,000 and the number of genera from 800 to 1,000. The species are widespread throughout the world and adapted to every possible habitat. In any particular area the composites are almost always the most numerous both in number of species and number of plants. The asters, goldenrods, blazing stars, sunflowers, ragweeds, thistles, beggar-ticks, ironweeds, etc., often constitute a very conspicuous part of the flora. In southern Florida there are well over one hundred species of composites ranging from the rather rare *Boltonia* of the everglades to the common *Bidens leucantha* of the fields and roadsides.

Some of the species native to this area flower in the spring months only (i.e. *Sachsia, Helenium vernale, Mesadenia, Chaptalia, Senecio, Eupatorium mikanioides*); others come into flower in late summer and persist through most of the fall (i.e. *Iva, Elephantopus, Carphephorus, Trilisa, Euthamia, Chondrophora, Baccharis*). Many, however, can be found flowering in any month of the year (i.e. *Pluchea, Bidens, Seneciodes, Conoclinum, Borrichia, Flaveria, Heterotheca*).

Occasionally certain species will be found flowering in the winter months (especially in burnt over pinelands and fields) when their regular season is late summer (for example, *Cirsium, Liatris, Chrysopsis, Solidago,* and *Aster).* These plants are often much smaller, less prolific, and in general not typical of the species. This often

makes it difficult to identify some of the species and care should be used in collecting and studying these plants.

Plants. The majority of our composites are herbaceous annuals or perennials, some occasionally becoming woody at the base of the plant. A few are true shrubs (*Baccharis, Borrichia, Eupatorium villosum*); some are herbaceous vines (*Mikania)* and only one is a woody vine (*Aster carolinianus).* Some species are aromatic (*Ambrosia, Pluchea, Pectis).* In the subfamily *Cichorieae* the plants have milky juice. Taproots prevail in most species, and in some the taproot becomes thickened and more or less globular in shape *(Liatris, Melanthera, Chrysopsis, Pterocaulon).*

Leaves. The arrangement of leaves is alternate or opposite; in some species the leaves are all basal *(Sachsia);* some species have succulent leaves *(Borrichia).* Simple leaves prevail but compound leaves are not uncommon *(Bidens).* The shape, size, margin, and pubescence vary considerably.

Inflorescence. The individual flowers are sessile, borne on a common receptacle, and are surrounded by an involucre of usually green bracts — the entire structure called a head. [Plate I] This type of inflorescence is one of the main features that distinguishes this family. The heads are stalked or sessile and arranged in inflorescences of a second order, as a spike or raceme *(Liatris),* panicle *(Solidago),* corymb *(Chrysopsis),* or the heads may be solitary *(Helenium vernale).* The typical arrangement of the heads is a corymb.

Involucre. The flowers are surrounded by green (sometimes white or colored), often leaf-like or scale-like bracts (phyllaries) which make up the involucre. These bracts may be in one or more series, in the latter case they are said to be imbricated. In one group of the composites the bracts are in one series and united almost to their tips (as in *Mesadenia).* [Plate I, c.]

Receptacle. The sessile flowers are produced on a common receptacle which may be flat, rounded, cone shaped (as in *Rudbeckia),* smooth, pitted, honeycombed, etc., naked or with chaff. [Plate I, b.]

Chaff. In addition to the bracts subtending the inflorescence, each flower may be subtended by a bract, in which case the receptacle is said to be chaffy. The chaff often partially surrounds the flower and may persist on the achenes when they are mature. If the chaff is absent the receptacle is said to be naked. [Plate I, e.]

Flower. There are two types of flowers: (1) tubular flower in which the corolla is actinomorphic; (2) ligulate flower in which the corolla is zygomorphic, split down one side forming a strap-shaped structure, the ligule. Either or both types of flowers may make up the head. If only the tubular flowers are present the heads

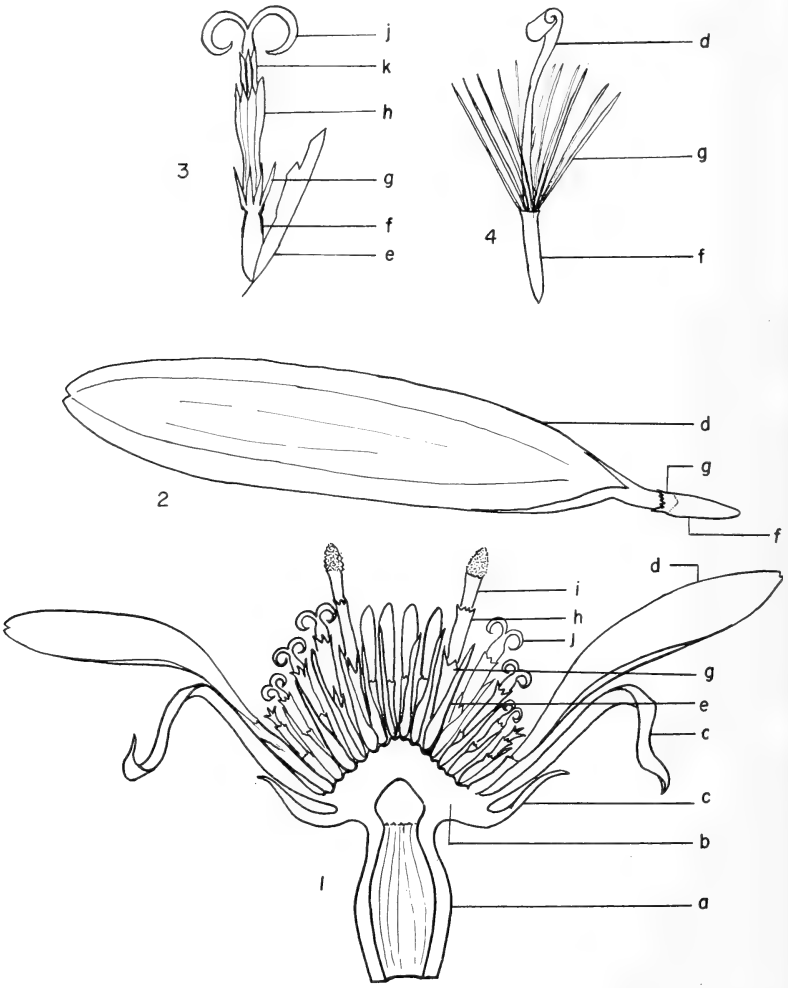

Plate I. 1. Longitudinal section of a radiate head. 2. Ray flower. 3. Disk flower with a scaly pappus. 4. Ray flower with a capillary pappus. a. peduncle. b. receptacle. c. bract. d. ligule of the ray flower. e. chaff. f. ovary. g. pappus. h. corolla of the disk flower. i. style. j. stigma. k. anther.

are said to be discoid (as in *Liatris).* If ligulate flowers are present and form the marginal flowers just within the involucre bracts, they are then called ray flowers. The tubular flowers which make up the rest of the head are then called the disk flowers. When the head contains these two types of flowers it is said to be radiate (as in *Aster).* In the third type of head all the flowers are ligulate and no tubular flowers are present (as in *Lactuca),* and this type of head is characteristic of the subfamily *Cichorieae.* In many cases in the radiate head, the ray flowers are neutral (no stamens or pistils) or pistillate only; the disk flowers are mostly perfect. In *Berlandiera* and *Parthenium* the ray flowers are perfect and fertile but the disk flowers are sterile. In the species of *Baccharis* the flowers are unisexual, the plants dioecious. In a few species the heads contain only one flower (the pistillate heads in *Ambrosia* and the heads in *Flaveria trinerva).* [Plate I, Fig. 2 & 3.]

Calyx. The calyx has been variously modified so it no longer resembles the calyx of other flowers. It may be merely a ring (i.e. *Ageratum),* a crown (i.e. *Eclipta),* a fringe of scales (i.e. *Borrichia, Gaillardia),* bristles (i.e. *Gnaphalum),* capillary hairs (i.e. *Aster),* awn-like (i.e. *Bidens),* or it may be absent (i.e. *Berlandiera, Flaveria, Rudbeckia).* In the Compositae the calyx is called the pappus. Often the pappus persists and plays a part in the distribution of the fruit. [Plate I, g.]

Corolla. There are five petals united to form a tube with the upper end usually enlarged to form a throat and then expanding into five lobes. The disk flowers are tubular, actinomorphic, and five lobed. The ray flowers are zygomorphic, split down one side so that the corolla is flat, and usually three lobed. In one tribe (represented here by *Chaptalia* and the cultivated *Gerbera)* the disk flowers are also zygomorphic, being two-lipped, and resemble somewhat mint flowers.

Stamens. There are five stamens and they are borne on the corolla tube. The anthers are united (the genus *Kuhnia* and the subfamily *Ambrosieae* being exceptions) to form a ring around the style. In certain groups (such as in the thistle tribe) the anthers are caudate, or tailed, at the base. [Plate I, k.]

Pistil. The pistil is composed of two united carpels, and the ovary is only one-celled. The ovary is inferior, the pappus and corolla are borne on top of the ovary. The style is usually two

parted, forming two lobes or branches. The stigmatic areas are on the upper side of the style branches, often forming lines. The styles have various types of pollen-collecting hairs, or brushes, located at the tips or on the under surface of the style branches. [Plate I, f, i, j.]

Fruit. The fruit is a one-seeded achene varing in size, shape and pubescence. In many cases the pappus remains on the fruit as a tuft of hairs, scales, barbs, etc., aiding in the dissemination of the fruit.

Summary of the Floral Characteristics of the Compositae. Flowers in a head, surrounded by an involucre of bracts and borne on a receptacle which may be chaffy or naked; calyx modified into a pappus or absent; corolla of five united petals (sympetalous), actinomorphic (tubular or disk flowers) or zygomorphic (ligulate or ray flowers), mostly perfect but often unisexual, the plants rarely monoecious or dioecious; stamens five, epipetalous and synantherous; pistil syncarpous, bicarpellate, ovary one-celled, inferior; style one with two branches; fruit an achene.

TRIBES

The different species of composites fall into more or less natural groups which are called tribes. Some of the tribes with familiar examples are the following: *Ambrosieae,* ragweeds; *Vernonieae,* ironweeds; *Eupatorieae,* blazing stars and bonesets; *Astereae,* asters and goldenrods; *Heliantheae,* sunflowers and tickseeds; *Cynareae,* thistles; *Anthemideae,* chrysanthemums; *Cichorieae,* chicory and wild lettuce. The tribes are not used in this work, since the number of species is not too great. Instead the species have been grouped into three subfamilies, *Ambrosieae, Astereae,* and *Cichorieae.* In some works (especially Small, 1933) these three groups are considered families.

HAY FEVER PLANTS

The subfamily *Ambrosieae* contains the ragweeds. These plants are wind pollinated and are most responsible for causing late summer and fall hay fever. In south Florida *Ambrosia elatoir,* the short ragweed, bitterweed, or hogweed, is found in great abundance during the spring and summer months in cultivated fields and along roadsides especially south of Miami. For various reasons the pollen of these plants is not particularly irritating to sensitive

persons. Mrs. Lillian Fly of the Botany Department of the University of Miami has made a study (1949) of the dispersion of the ragweed pollen which throws some light on this question. It was found from purely clinical evidence that the protein content of the pollen is either very low or is of a type which does not cause a reaction. Patients who suffered from northern ragweed hay fever showed little or no reaction to an injection of the south Florida ragweed pollen. Besides the possible low protein content, there are other factors involved. Our ragweed plants flower best in the late spring and summer months during the rainy season, and this might account for keeping the pollen count down. The amount of pollen produced in a head is as much as is produced by ragweed plants that grow in the northeastern United States. Yet the amount of pollen that is actually liberated into the air is practically negligible. Slides exposed on a dry windy summer day in various places in and around a field of ragweed, yield practically no ragweed pollen, thus showing that the pollen is just not being shed by the plants. It may be that our *Ambrosia elatoir* plants are undergoing a transition from wind to insect pollination, and the pollen perhaps is becoming heavier and more glutinous and is thus not blown out of the head. Species of ants and other crawling insects may be the actual agents which bring about the pollination. It is quite possible that our ragweed might be considered a distinct physiological species.

It is surprising how many people still persist in believing that goldenrods *(Solidago)* cause hay fever. Goldenrods are insect pollinated and it is only the wind pollinated plants that cause hay fever. It is possible, however, for a sensitive person to suffer from goldenrods and other insect pollinated plants if he comes in close contact with the flowers or if the flowers are cut and allowed to dry and the pollen is then shed in the vicinity of the sensitive person. The fact that the goldenrods with their conspicuous yellow heads are usually found flowering in the same months as the inconspicuous ragweeds probably leads to the belief that the goldenrods are the cause of hay fever.

SOILS

Of the many factors which affect plant distribution, one of the most important is the nature of the soil. The acidity and alkalinity of the soil play a great part in determining what plants grow in any particular type of soil. Some plants, like the members of the

heath family, will grow only in an acid soil. Other plants will grow only in an alkaline soil. Still others tolerate either an acid or alkaline soil.

In studying the distribution of the composites in this area soil samples were taken immediately surrounding the roots of the plants and the pH of the soil tested with the colorometric method. It was found that many of the composites that grow in the pine flatlands north of this area find their southern range in the acid sands of Broward County, northern Dade County, Marco Island, and just north of Naples. The Pamlico sands in these areas are quite acid ranging in pH from 4.5 to 6.0. Around Ft. Lauderdale these acid sands represent ancient sand dunes and are covered with a scrub vegetation. The composites characteristic of this soil are the following:

Euthamia minor
Eupatorium recurvans
Carphephorus corymbosus
Palafoxia Feayi
Elephantopus tomentosus
Actinospermum angustifolium
Chrysopsis floridana
Chondrophora nudata
Trilisa odoratisima
Seriocarpus bifoliatus
Aster patens
Lygodesma aphylla
Solidago fistulosa
Polypteris integrifolia

The sand in Dade County, especially around Miami, Coconut Grove, near Chapman Field, and a few areas in Pinecrest, occurs as a thin layer or as pockets over the Miami oolite. These sands are less acid, tending toward a pH of 7 or neutral because of the influence of the limestone. Several of the acid loving composites which will grow as far south as Coconut Grove in this sand, which has a pH of 6.4 to 7.0, are:

Actinospermum angustifolium
Polypteris integrifolia
Chrysopsis hyssopifolia
Palafoxia Feayi
Erigeron vernus
Seriocarpus bifoliatus

The rest of this region has soil which is predominately alkaline — Miami oolite, prairies, the salt flats, and the beach sands.

Over most of Dade County south of Miami the Miami oolitic limestone is found at the surface with very little soil present. The soil belongs to the Rockdale series and around Homestead is called

Redland soil. The composites that grow in the Miami pineland tolerate alkaline soil which has a pH of 7.2 to 8.0. Some of the species which grow in this soil are the following:

Melanthera radiata
Melanthera angustifolia
Flaveria linearis
Berlandiera subacaulis
Eupatorium villosum
Chaptalia dentata
Sachsia bahamensis

Marl overlying Miami oolitic limestone forms glades in the Miami pineland and makes up most of the southeast coast. The glades were probably rivers at one time draining the everglades basin. The marl is fresh water marl and supports wet prairies, marshes, etc., and the vegetation is often similar to that of the everglades because, as will be pointed out further on, the peat in the everglades is only slightly acid. The pH of the marl is from 7.5 to 8.6. In the Cape Sable region the Flamingo marl is of marine origin and it is highly alkaline with a pH as high as 9.3. A few of the characteristic plants of the marl prairies and low pinelands with a thin covering of marl are:

Flaveria linearis
Vernonia Blodgettii
Iva microcephala
Mikania batatifolia
Helenium vernale

Salt flats and marshes near the coast have marly soils and are alkaline, with a pH of 8.2 to 8.6. A few of the plants found in these salt flats and marshes are:

Borrichia frutescens
Baccharis halimifolia
Ageratum littorale

The beach sands of course are alkaline and composites that grow on or near the beach tolerate, among other things, an alkaline soil with a pH of 7.8 to 8.2.

Iva imbricata
Helianthus debilis
Flaveria trinerva

Flaveria latifolia
Ambrosia hispida
Melanthera deltoidea

On the other hand there are many species that tolerate either acid or alkaline soils. These species are found growing in the acid soils as well as the alkaline soils that prevail over most of this area. They are:

Chrysopsis graminifolia
Liatris Chapmanii
Liatris chlorolepis
Liatris tenuifolia
Pluchea foetida
Pterocaulon undulatum
Solidago Chapmanii
Solidago stricta

The everglades marshes and prairies have a soil which is made up of peat and in many places marl. This soil varies in thickness from a few feet to several feet; often there is very little soil, the Miami oolitic limestone being exposed at the surface. Peat is usually acid, but because the everglades peat is associated with limestone and marl (Ft. Thompson limestone, Caloosahatchee marl, Tamiami sandy limestone, Lake Flint marl, and Miami oolite), the peat is only slightly acid or neutral, or even alkaline. In the sawgrass marshes with the Everglades and Brighton peats the pH varies from 6.85 to 7.72 (Davis 1943). In the cypress swamps the soil is slightly acid to slightly alkaline because the limestone is so close to the surface. Because the peat is neutral or alkaline many of the plants that grow in the marl prairies will also be found in the everglades.

Summary: Where the Pamlico sands form a thick cover and are not influenced by the underlying limestone, the soil is highly acid (pH 4.5 to 5.0) and only the acid tolerant plants are found growing in this soil. Where the sands form only a thin layer over the limestone or occur as pockets in the limestone, these sands tend toward neutral or may be slightly alkaline (pH 6.2 to 7.2) and a few of the acid loving plants grow in the soil. Alkaline soils prevail, however, over most of this area — the beaches (pH 7.8 to 8.2), Miami pinelands and the Keys (pH 7.2 to 8.2), the marl prairies (pH 7.8 to 8.6), the salt flats and marshes (pH 8.2 to 8.6), and the everglades (pH 6.8 to 7.7).

VEGETATION

The area covered in this report is part of the Coastal Lowlands; Davis (1943) recognizes eight physiographic regions in this area: Western Flatlands, Eastern Flatlands, Big Cypress Swamp, Everglades Basin, Southwest Coast and Ten Thousand Islands, Southern Coast and Islands, the Florida Keys, and the Miami Rock Ridge and Atlantic Coast Strip. These regions are quite distinct and have many characteristics which set them apart as definite units. However, several types of vegetation are often found in one particular region. Therefore the types of vegetation, instead of the physiographic regions, will be discussed briefly, and the composites characteristic of these vegetational areas will be given.

Coastal Beach and Dune Vegetation. Coastal beach and dune vegetation is found on sandy beaches along the ocean front and on the sand dunes of recent origin behind the beaches. Beaches can be found on the Atlantic shore down to Elliott's Key, on the west coast near Naples, on Marco Island, Cape Romano, Cape Sable, on the Keys, especially on Lower Matecumbe Key, and on the Sand Keys off Key West. Beach vegetation develops on shores with a steep slope; but if the shore has a low or gradual slope, mangrove swamps will develop. Beach vegetation grades into scrub, beach hammock, or pineland where the beaches are high; into mangrove swamps, salt marshes, or wet prairies where the beaches are low. The plants that tolerate a sandy alkaline soil, intense light, and salt spray are called physiological xerophytes. Many of the beach plants are found on beaches throughout the West Indies. The typical beach composites are: *Ambrosia hispida, Helianthus debilis, Iva imbricata,* and *Melanthera deltoidea.*

Mangrove Swamps, Salt Flats, Salt Marshes and Salt Prairies. Mangrove swamps are found in shallow ocean water where the wave action is negligible. Mangrove swamps may develop on sand, marl or muck. Where the mangroves develop on sand several beach plants are also present; if they develop on marl or muck many salt loving marsh plants are present. Mangroves grow as far north as Cedar Keys on the West Coast and St. Augustine on the east coast. The mangroves form large areas on the Southwest Coast and Ten Thousand Islands, are abundant on Cape Sable and the South Coast Islands, and are found on both sea and bay sides of the Keys. The soil of mangrove swamps may be peat

and slightly acid to alkaline (pH 6.3 to 8.1, Davis, 1943); or it may be marl and alkaline (pH 7.5, Davis, 1943).

Mangrove swamps grade into salt flats, salt marshes, or salt prairies and often mangrove trees are found growing in these areas. The salt flats, marshes and prairies are found near the ocean, are inundated often by salt water at high tide but are not affected by wave action. Sometimes salt flats develop behind the beaches where the land is low. The Southern Coast region is made up mostly of salt flats and marshes. The soil of salt flats, salt marshes and salt prairies may be sand, muck, marl or peat, and usually is highly alkaline.

The different species of *Baccharis, Borrichia,* and *Pluchea* are common in these salt areas. In addition *Solidago sempervirens, Iva frutescens,* and *Eupatorium serotinum* can be found. *Ageratum littorale* is found on the Keys. On Cape Sable and Key Largo in the more mature hammocks the two species of *Osmia* are found.

Fresh Water Marshes and Wet Prairies. Fresh water marshes are characterized by tall plants such as sedges, reeds, rushes, grasses, and a few broad-leaved herbs of aquatic habitats. Wet prairies are dominated by more grasses, and less surface water is present. Marsh prairies have both marsh and prairie vegetation. The everglades is one of the largest fresh water marshes, containing more than 1,250,000 acres. A sedge, *Cladium,* is the dominant plant. The glades in the Miami pineland are mostly wet prairies and grade into low pinelands where the marl is a thin covering over limestone. The soil of fresh water marshes and wet prairies is usually alkaline. For this reason many marsh and prairie plants found growing further north in the bog soils of the low acid pinelands are conspicuously absent from our area. The composites that grow in our fresh water marshes and wet prairies are alkaline tolerant, and when they grow in dry soil they are found also in the adjacent pinelands. The composites that can be found in fresh water marshes and wet prairies are the following:

Aster Bracei
Aster dumosus
Aster exilis
Aster Simmondsii
Baccharis halimifolia
Baccharis glomerulifolia
Boltonia diffusa
Cirsium horridulum
Conoclinum coelestinum
Coreopsis Leavenworthii
Coreopsis gladiata
Eupatorium capillifolium
Eupatorium leptophyllum
Eupatorium mikanioides

Eupatorium serotinum
Erigeron quercifolius
Flaveria floridana
Flaveria latifolia
Flaveria linearis
Helenium vernale
Helenium nudiflorum
Iva microcephala
Mesadenia Elliottii
Mesadenia lanceolata
Mikania batatifolia
Pluchea foetida
Pluchea petiolata
Pluchea purpurascens
Senecio glabellus
Solidago angustifolia
Solidago fistulosa
Solidago sempervirens
Spilanthes repens
Vernonia Blodgettii

Cypress Swamps. Cypress swamps are flooded forests that are inundated by shallow surface water part of the year. Because cypress seedlings require atmospheric oxygen, the cypress swamps occur only where the water level recedes below the soil surface at certain times of the year. Cypress swamps occur in the form of domes, heads, strands, or scrub. The latter are open and have prairie or marsh land vegetation with scattered cypress trees. The domes and heads are usually well developed cypress hammocks. Cypress swamps develop on sand or on marl over limestone. Cypress swamps in this area are found mostly in Collier County beyond the "Forty Mile Bend", but they are also in northern Monroe County in the Pinecrest area, and bordering the pineland on the west side of Broward County. In western Collier County the cypress is mixed with pine and the soil is sandy. Two species of composites are more or less characteristic of cypress swamps and hammocks — *Aster carolinianus*, climbing aster, and *Spilanthes repens*, the latter often forming extensive mats.

Hammocks. Hammocks are islands of trees and shrubs surrounded by other types of vegetation. The plants are mainly tropical species (See Phillips, 1940). Six types of hammocks have been recognized: Key Largo hammocks on coral rock, Big Pine Key hammocks on oolite, Cape Sable hammocks on marl, Miami pineland hammocks on oolite, coastal hammocks on sand, and bay tree hammocks in the everglades on very acid peat. Few species of composites are found in the hammock because the shade is too dense to allow most herbaceous plants to grow. The composites which may be found in the hammocks are: *Eupatorium villosum* a tropical shrub more often found in the pinelands at the edges of hammocks as a pioneer plant; *Osmia odorata* found in the Cape Sable and Key Largo hammocks; a vine *Mikania cordifolia* found in open ham-

mocks; and *Verbesina laciniata,* a weedy plant, found in the hammocks but more often on their margins.

Scrub and Sandy Pinelands. Scrub pinelands on ancient sand dunes form a narrow strip on the east coast as far south as Ft. Lauderdale in Broward County. On the west coast they are found on Marco Island and north of Naples. The soil is white quartz sand with some organic material and is highly acid. There are many scrub oaks and other plants such as sand pine, rosemary, Selaginella, and species of the lichen *Cladonia.* There are few grasses or herbs.

The sandy pinelands are found in North Miami extending northward along the coast. The soil consists of Pamlico sands overlying the Miami oolite. The soil is acid, and many of the acid loving plants found in the scrub areas are also found in the sandy pinelands. These acid sands thin out in the Miami area and are present only as pockets of sand scattered in the Miami oolite. Many of the acid loving plants found in the sandy acid soil of the flatlands further north and in the scrub lands of Broward County find their southern limit in the acid pockets of the Miami region and in Pinecrest.

Some of the plants found in the scrub lands, the sandy pinelands and the acid pockets of the Miami region are:

Actinospermum angustifolium
Aster patens (at Pinecrest)
Carphephorus corymbosus
Elephantopus tomentosus
Liatris
Palafoxia Feayi
Polypteris integrifolia
Pterocaulon integrifolia
Seriocarpus bifoliatus
Trilisa odoratissima

Two species found in the scrub land and not in the sandy pinelands are:

Chrysopsis floridana
Lygodesma aphylla

Within the pinelands and scrub lands are low areas in which the soil is sandy loam (the Half Bog soils, Henderson, 1939) and water is present at the surface for part of the year. In these low areas are found acid and moisture loving plants which are conspicuously absent over most of the area further south. Two species of composites that are typical of these low lands in our area are *Eupatorium recurvans* and *Euthamia minor.*

Miami Pine Forests. In Dade County from Miami south to Homestead and from there southwest into the Everglades (forming

the Everglade Keys or Long Pine Key) the Miami oolitic limestone is at the surface with little if any covering of sand. What soil there is, is quite alkaline. The Miami rock pineland is broken up into more or less rock islands by the glades. These glades extend from the wet prairies of the everglades on the north and west side of the pinelands through the pinelands to the Southern Coast marsh prairies. Many of the Miami pineland composites also grow on the Key Largo coral rock of the upper Keys and the Miami oolite on the lower Keys. *Pinus caribaea,* the slash pine, is the dominant plant in these pine forests. Between the glades and the pinelands is a transitional area, the low pinelands. Here the marl of the glades forms a thin covering over the limestone of the pinelands. The pines and palmettoes thin out, and many of the typical dry pineland plants and glade plants are absent in this transitional area. Some species, however, are found in both areas since the soil is alkaline in both the pinelands and the glades. On the other hand there are some species that are considered typical of the low pineland; some of these are *Aster Simmondsii, Coreopsis Leavenworthii, Coreopsis gladiata, Flaveria linearis, Melanthera angustifolia, Mesadenia lanceolata,* and *Vernonia Blodgettii.*

The composites that can be found in the Miami pinelands are:

Aster adnatus
Aster dumosus
Aster Simmondsii
Aster simulatus
Baccharis angustifolia
Baccharis halimifolia
Berlandiera subacaulis
Chaptalia dentata
Chrysopsis graminifolia
Chrysopsis microcephala
Chrysopsis Tracyi
Cirsium horridulum
Coreopsis Leavenworthii
Eupatorium compositaefolium
Eupatorium juncundum
Eupatorium villosum
Erigeron quercifolius
Flaveria linearis
Heterotheca subaxillaris
Hieracium magacephalon
Kuhnia Mosieri
Liatris Chapmanii
Liatris chlorolepis
Liatris tenuifolia
Melanthera angustifolia
Melanthera parviflora
Melanthera radiata
Mikania batatifolia
Pluchea foetida
Petocaulon undulatum
Sachsia bahamensis
Solidago Chapmanii
Solidago Leavenworthii
Solidago stricta
Solidago tortifolia
Tithonia diversifolia
Verbesina laciniata
Vernonia Blodgettii

Weeds. About ¼ of the composites of South Florida may be considered as weeds. They grow along roadsides, railroad tracks and

embankments, in lawns, gardens, cultivated areas, fields, etc., wherever the soil has been disturbed. The composites that are considered as weeds are the following:

Ambrosia elatoir
Aster inconspicuus
Bidens leucantha
Calyptocarpus vialis
Eclipta alba
Eupatorium capillifolium
Eupatorium leptophyllum
Erigeron quercifolius
Erigeron ramosus
Emilia coccinea
Erechtites hieracifolia
Flaveria trinerva
Galinsoga ciliata
Gnaphalum falcatum
Gnaphalum polycephalum
Helenium tenuifolium
Heterotheca subaxillaris
Lactuca graminifolia
Lactuca intybacea
Leptilon canadense
Leptilon pusillum
Parthenium hysterophorus
Pectis leptocaphala
Pectis prostrata
Seneciodes cinera
Sonchus asper
Sonchus oleraceus
Tridax procumbens
Verbesina laciniata

STATISTICS

One hundred and twenty-five species of composites, representing 62 genera, that grow in this area have been collected and described. An attempt has been made to analyze the geographical distribution of these species to determine what percentage of the species are "tropical". In order to do this the geographical distribution of the species has been studied in three ways: (1) the distribution of all the species as they occur in the United States; (2) the distribution of only the "tropical" species as they occur in the United States; and (3) the distribution of the species as they occur outside of the United States.

Distribution of the Species As They Occur in the United States. A study of the distribution of the composites of this area as they occur in the United States shows that 34% (representing 42 species) are restricted to Florida, and 66% (or 83 species) range beyond the northern border of Florida (See table).

Endemic species. 8% of the species are restricted to that part of Florida that lies south of Lake Okeechobee and are therefore considered endemic to south Florida. They are found in no other area. These 10 species which are considered endemic are the following:

Ageratum littorale
Aster simulatus
Chrysopsis Tracyi
Flaveria floridana

Flaveria latifolia
Melanthera parviflora
Melanthera radiata
Osmia frustrata
Palafoxia Feayi
Vernonia Blodgettii

Eleven other species restricted to Florida have been reported from further up the state, especially in the Gainesville area (Beck, 1943; Murrill, 1945):

Aster Bracei
Aster Simmondsii
Berlandiera subacaulis
Chrysopsis floridana
Coreopsis Leavenworthii
Eupatorium juncundum
Eupatorium mikanioides
Kuhnia Mosieri
Liatris chlorolepis
Liatris laevigata
Solidago angustifolia

South Florida species found in the West Indies and other countries. Seventeen percent (representing 21 species) of the composites that are found in the United States only in South Florida are also found in the West Indies and other countries. These species, perhaps, are the true tropical composites in our area. Many of them range throughout the West Indies; some are also found in Mexico, Central and South America; a few are found only in the Bahamas and south Florida. These species which may be considered as the true tropical composites in our area are the following:

Ambrosia hispida
Aster inconspicuus
Baccharis dioica
Borrichia arborescens
Chaptalia dentata
Eupatorium villosum
Emilia coccinea
Flaveria linearis
Lactuca intybacea
Melanthera angustifolia
Melanthera deltoidea
Mikania batatifolia
Mikania cordifolia
Osmia odorata
Pectis leptocephala
Pluchea odorata
Sachsia bahamensis
Seneciodes cinera
Tithonia diversifolia
Tridax procumbens
Wedelia trilobata

Species ranging beyond the northern border of Florida. Sixty-six percent of the south Florida composites occur in states north of Florida. Some of them are limited to southeastern United States (39%); but many (27%) are found in northeastern United States north of Virginia, some reaching the New England states, and even a few are found in Canada. Several of the latter are weeds which are almost universal in distribution.

DISTRIBUTION OF SOUTH FLORIDA COMPOSITES AS THEY OCCUR IN THE UNITED STATES

IN FLORIDA ONLY		RANGING NORTH OF FLORIDA			TOTAL
34%		66%			100%
Endemic	Ranging to Gainesville	South Florida & West Indies	Southeastern United States	Northeastern United States	
8%	9%	17%	39%	27%	100%

Distribution In United States of the "Tropical" Composites That Are Also Found In Other Countries. In analyzing the geographical ranges of the species as they occur outside of the United States, it was found that nearly half of the 125 species, or 48%, are found in the West Indies, Mexico, Central America, and/or South America. Twenty-one of these species are not found in the United States, outside of Florida, and these probably are our true tropical composites (see above). Thirty-seven of the 125 species (representing 30%) are found in the states north of Florida. Of these 37 species, 15 are found in the southeastern states and 22 are found in the northeastern states north of Virginia.

DISTRIBUTION IN UNITED STATES OF "TROPICAL" COMPOSITES ALSO FOUND IN THE WEST INDIES, MEXICO, CENTRAL AMERICA, SOUTH AMERICA

IN FLORIDA ONLY	RANGING NORTH OF FLORIDA		TOTAL
18%	30%		48%
	Southeastern United States 12%	Northeastern United States 18%	

Distribution of the Species Outside of the United States. As mentioned previously, 48% of the 125 species (representing 60 species) are found in other countries. Of the total number of species 46% are found in the West Indies. More species are found in Cuba (38%) than any other West Indian Island. The following table gives the percentage of our composites that are found in the different West Indian countries, Mexico, Central America, and South America.

West Indies	46%
Cuba	38%
Bahamas	32%
Dominican Republic	25%
Haiti	21%
Puerto Rico	18%
Jamaica	18%
Virgin Islands	14%
Trinidad	16%
Mexico	22%
Central America	27%
South America	16%

It is surprising that more tropical species of composites do not grow in south Florida; one would particularly expect the composites of the Keys to have a greater affinity with the composites of the Bahamas. Phillips (1940) finds 82% of the plants growing in a tropical hammock (Castellow) just below Miami also grow in the West Indies. Of the trees and palms listed in Buswell's *Native Trees and Palms of South Florida* (1945) approximately 74% are also found in the West Indies; and in Buswell's *Native Shrubs of South Florida* (1946) 61% of the species given are found in the West Indies. Woodbury (1948) finds that 67% of the mosses in Dade County are found in the West Indies. Yet only 46% of our composites are found in the West Indies, and many of these species grow in the southern and northern states as well; only 21 species, or 17%, occur exclusively in South Florida and the West Indies.

The tropical trees, shrubs, and mosses that are found in South Florida are mainly found in the hammocks where there is some protection from the occasional frosts. However, most of the composites grow in the open and do not tolerate dense shade, and therefore do not grow in the frost-free hammocks. This is probably one of the main reasons why there are so few species of tropical composites in south Florida. Many more tropical composites probably would grow here if they were protected from frosts as are the hammock plants. Other possible climatic factors to be considered as limiting factors for the entry and successful establishment of tropical composites are the following: the low precipitation on the Keys; the lack of suitable soil in the Miami pineland and the Keys; the alkalinity of the soil that prevails over most of this area; and the inability

of the rocks and soils to hold water and thereby creating soils with a low moisture content.

Most of the tropical trees and shrubs of the West Indies that are found in South Florida have berry or berry-like fruits which are eaten by the birds. Thus these birds, especially the migrating birds, act as agents in distributing the plants from one country or area to another. The composites, on the other hand, do not have fruits of this type; hence perhaps the lack of the bird-eating fruits in this family might be another factor to account for the few tropical composites in South Florida.

Furthermore, this family of plants is essentially a temperate one, that is, the majority of species are found in temperate climates and relatively few are found in the tropics. Therefore, perhaps, one would expect that the majority of composites in south Florida would be of the temperate climate type rather than from the tropics. If we compare the composite family with the madder family (Rubiaceae), which is a tropical family, we find the latter represented in south Florida by 37 species, 30 (or 81%) of which are tropical species found in the West Indies, Central and South America.

Although the hammock flora consisting of trees and shrubs may be considered as having a close affinity with the West Indian flora, the composite flora consisting of mostly herbaceous plants cannot be considered as having nearly as great an affinity. The composite flora seems to be more closely allied to the flora of the southeastern United States.

In summary, using round figures, our composite flora may be said to be distributed approximately as follows:

8% of the species are endemic.

⅓ of the species in United States are limited to Florida.

⅔ of the species range beyond the northern border of Florida.

¼ of the species reach the northern states.

17% of the species are found exclusively in South Florida and the West Indies.

½ of the species are found in the West Indies, Mexico, Central America, South America.

The composite flora seems to be unstable. Several species appear to be progressing southward. They may be of sporadic occurrence and may never have been successful in becoming established. Also there is the possibility that these have been overlooked by previous

collectors. The following species that have been collected only recently are the following:

Calyptocarpus vialis
Chrysopsis hyssopifolia
Erigeron ramosus
Flaveria trinerva
Galinsoga ciliata
Gnaphalum polycephalum
Erigeron vernus
Helenium nudiflorum
Helenium tenuifolium
Lactuca floridana
Lactuca graminifolia
Liatris chlorolepis
Liatris spicata
Pectis prostrata
Rudbeckia hirta
Senecio glabellus

On the other hand only a few species have entered from the West Indies and are, perhaps, progressing northward. These are:

Aster inconspicuus
Lactuca intybacea
Osmia odorata
Pluchea odorata
Seneciodes cinera

The Key to the Subfamilies and Genera of Compositae of South Florida

The key to the genera of south Florida composites is based mainly on vegetative characters. Since it is necessary to have specimens that are in flower in order to determine if the plant is a composite, floral characters such as the color of the flowers, nature of the pappus, presence or absence of chaff, the nature of the bracts of the involucre, and most important, whether the head is radiate or discoid, have been used in the key. These characters have to be observed while studying the flower before one can attempt to use the key.

It is important to remember that vegetative characters are not always as stable as floral characters. The vegetative characters may vary with different habitats (*Circium horridulum* for instance) and with different genetical make up of the plant (probably some specimens of *Coreopsis Leavenworthii).* But floral characters are, as a rule, rather stable. On the other hand one must realize that the composite family as a whole seems to be still undergoing evolutionary change by mutation, chromosome change, and hybridization (species of *Liatris)* and many species have not as yet become stable specific entities. Evidence of this can be found in the multitude of

variation one finds within individual species of composites, especially in the genus *Helianthus* studied by Watson (1928).

Because of these ecological and genetical variations individual plants may not always key out correctly and may not always agree with the description. It is necessary, therefore, to collect several plants of the same species and to study them carefully before attempting to work the key. After a plant has been identified by the key then turn to the genus and proceed to determine the species. In many cases no description of the genus has been given, but where several species of a particular genus are found in our area, a brief description of the genus is given and this is followed by a key to the species and descriptions of the species. A glossary has been included for those who are not too familiar with the terminology in this work.

1. Flowers all tubular and alike.
   2. Heads small, cup-shaped, greenish, drooping, borne in spikes and racemes ..... Subfamily *Ambrosieae*
   2. Heads various but most always erect and mostly in corymbs and usually colored or white ..... Subfamily *Astereae*
1. Flowers not all tubular, some (marginal) or all the flowers ligulate.
   2. Flowers of two types: (1) disk or tubular flowers in the center of the head, (2) ligulate or ray flowers on the margin of the head; plants without milky juice ..... Subfamily *Astereae*
   2. Heads composed of all ligulate flowers; plants with milky juice ..... Subfamily *Cichorieae*

Subfamily AMBROSIEAE

1. Leaves divided or deeply lobed or toothed; heads unisexual ..... 1. *Ambrosia*
1. Leaves entire or serrate but never lobed or divided; heads with both staminate and pistillate flowers ..... 2. *Iva*

Subfamily ASTEREAE

1. Heads discoid, the flowers all tubular and alike.
   2. Leaves compound or pinnatifid, at least on the lower part of the stem and on new shoots; upper leaves may be simple; leaves or divisions of the leaf filiform or narrowly linear ..... 8. *Eupatorium*
   2. Leaves simple, not filiform or linear, or if narrow never compound.
      3. Leaves opposite, especially on the lower part of the stem.
         4. Herbaceous Vines; flowers white or pinkish ..... 11. *Mikania*
         4. Not vines; flowers blue, white or yellow.
            5. Flowers blue.
               6. Pappus capillary; leaves not succulent.
                  7. Margins of the leaves crenate; receptacle conic ..... 9. *Conoclinum*

7. Margins of the leaves dentate; receptacle flat ..... 7. *Osmia*
6. Pappus a mere crown barely visible; leaves somewhat succulent ..... 6. *Ageratum*

5. Flowers yellow, white or pinkish.
6. Flowers yellow ..... 51. *Flaveria*
6. Flowers not yellow.
7. Bracts white, petaloid; leaf margin entire but ciliated; leaves scabrous ..... 49. *Polypteris*
7. Bracts not petaloid, more or less green or greenish white; leaf margin entire or serrate.
8. Leaves scabrous; heads mostly over 1 cm. wide; chaff present; pappus of two deciduous awns ..... 33. *Melanthera*
8. Leaves glabrous or soft pubescent but not rough; heads under 1 cm. wide; chaff absent; pappus capillary.
9. Leaves and branches borne horizontally, 4 ranked; involucre over 6 mm. long; involucre bracts in more than three series ..... 7. *Osmia*
9. Leaves and branches borne vertically (except *E. mikanioides);* involucre less than 6 mm. long; involucre bracts in one to few series ..... 8. *Eupatorium*

3. Leaves alternate or mainly basal.
4. Main leaves basal; stem leaves, if present, much reduced or scale-like.
5. Leaves pubescent.
6. Pubescence soft or scabrous but not white woolly.
7. Heads few flowered (about 3), clustered and involucred; flowers purplish; basal leaves over 8 cm. long and 3 cm. wide; leaf margin crenate-dentate ..... 5. *Elephantopus*
7. Heads many flowered, not clustered nor involucred; flowers white; basal leaves less than 8 cm. long and 3 cm. wide; leaf margin toothed ..... 27. *Sachsia*
6. Pubescence white woolly on the underside of the leaf; heads solitary; flowers very narrow and inconspicuous, white ..... 58. *Chaptalia*
5. Leaves glabrous or with a few cilia on margins of the leaf; leaves entire, grass-like ..... 13. *Liatris*
4. Stems leafy, often gradually reduced in size from the base to the top of the plant.
5. Leaves aromatic.
6. Leaves glabrous.
7. Shrubs; heads unisexual; flowers whitish; leaves usually with a resinous odor; stem leaves not

clasping ..... 25. *Baccharis*

7. Herbs; heads perfect; flowers rose-purple; leaves usually with a vanilla-like odor; stem leaves clasping ..... 14. *Trilisa*

6. Leaves pubescent; herbs or shrubs; leaves usually with a camphor-like odor ..... 26. *Pluchea*

5. Leaves not aromatic.

6. Shrubs.

7. Leaves glabrous; heads unisexual; flowers whitish ..... 25. *Baccharis*

7. Leaves pubescent; flowers rose or purple or pinkish white; heads perfect.

8. Leaves soft pubescent; flowers rose-purple; leaves over 8 cm. long ..... 26. *Pluchea*

8. Leaves scabrous; flowers white to pinkish; leaves less than 8 cm. long ..... 50. *Palafoxia*

6. Herbs (sometimes woody at base of plant).

7. Stem leaves conspicuously decurrent forming a winged stem.

8. Plants densely white woolly on stem and lower surface of the leaves, upper surface of leaves dark green ..... 28. *Pterocaulon*

8. Stems and leaves scabrous, not white woolly ..... 47. *Helenium*

7. Leaves not decurrent.

8. Leaves sessile or essentially so (blades of the lower leaves may narrow to a winged petiole).

9. Leaves glabrous.

10. Leaves entire.

11. Flowers rose-purple.

12. Heads in elongated spikes or racemes ..... 13. *Liatris*

12. Heads in corymbs.

13. Stem leaves linear, not clasping ..... 3. *Vernonia*

13. Stem leaves not linear, clasping.

14. Stem glabrous, receptacle naked; corymb much branched; involucre 5-6 mm. high ..... 14. *Trilisa*

14. Stem pubescent; receptacle chaffy; corymb little branched; involucre 8-10 mm. high ..... 10. *Carphephorus*

11. Flowers white, cream color or yellow.
    12. Plants glabrous throughout; at least some leaves over 3 cm. long.
        13. Flowers yellow; stem leaves linear; basal leaves narrowly spatulate; leaves dark green, only midrib evident; bracts of the involucre in several series ..... 15. *Chondrophora*
        13. Flowers white or cream color; leaves lanceolate or ovate, light green, 3-5 veined; bracts of the involucre in one series ..... 54. *Mesadenia*
    12. Stem finely pubescent; leaves linear, 1 veined; all leaves under 3 cm. long ..... 12. *Kuhnia*
10. Leaves serrate.
    11. Leaves oblanceolate or elliptic; stem leaves clasping ..... 14. *Trilisa*
    11. Leaves linear, none of them clasping ..... 3. *Vernonia*

9. Leaves pubescent.
    10. Leaf margins with spreading spines; heads with an involucre of leaf-like and weak spine tipped bracts ..... 57. *Cirsium*
    10. Leaf margins without spines; heads not involucred with spine tipped bracts.
        11. Pubescence densely white woolly; heads clustered, compact, and densely white tomentose ..... 29. *Gnaphalum*
        11. Pubescence not densely white woolly; heads not compactly clustered.
            12. Flowers rose-purple; heads in elongated spikes or racemes; leaves linear ..... 13. *Liatris*
            12. Flowers pale lilac to pink, red or white; heads not in elongated spikes or racemes.
                13. At least some of the leaves clasping or auricled at the base.
                    14. Leaf margins deeply lobed or incised; flowers whitish .. 55. *Erechtites*
                    14. Leaf margins merely

serrate; flowers bright red or scarlet ..... 53. *Emilia*

13. None of the leaf bases clasping or auricled.
    14. Bracts of the involucre white and petioled; flowers pinkish white, showy, leaves lanceolate ..... 49. *Polypteris*
    14. Bracts of the involucre not petaloid; flowers white or lilac, not showy; leaves spatulate or linear.
        15. Leaves spatulate to ovate; flowers lilac to white; heads not numerous, corymbose..4. *Seneciodes*
        15. Leaves linear; flowers white; heads very numerous, panicled ..... 24. *Leptilon*

8. Leaves petioled (sometimes only a very short petiole)
    9. Leaves glabrous.
        10. Flowers rose-purple; bracts in more than one series, not united ..... 3. *Vernonia*
        10. Flowers white or pink-tinged; bracts in one series, united ..... 54. *Mesadenia*
    9. Leaves pubescent or scabrous.
        10. Leaves soft hairy, serrate, spatulate to ovate; flowers pale lilac to white ..... 4. *Seneciodes*
        10. Leaves scabrous, entire, lanceolate to elliptic; flowers white to pinkish white.
            11. Bracts of the involucre white and petaloid; pappus of awn-like scales, capillary-like ..... 49. *Polypteris*
            11. Bracts of the involucre not white nor petaloid, bracts small, narrow, red-tipped, pappus of short broad scales ..... 50. *Palafoxia*

1. Heads radiate, flowers of two types; tubular disk flowers and ligulate ray flowers.

2. Leaves opposite.
   3. Low shrubs with thick leaves and large heads with showy yellow ligules ..... 37. *Borrichia*
   3. Herbaceous plants, not woody (or if woody only at base of the plant).
      4. Leaves compound, especially on lower part of the plant.
         5. Rays white ..... 43. *Bidens*
         5. Rays yellow ..... 42. *Coreopsis*
      4. Leaves simple.
         5. At least some of the leaves 3-lobed; margin of leaf dentate; sprawling vine ..... 36. *Wedelia*
         5. Leaves not 3-lobed; margins of leaf entire, toothed or incised.
            6. Leaves with oil glands on lower surface and long cilia on the margins near the base; plants aromatic ..... 52. *Pectis*
            6. Leaves without oil glands and cilia, plants not aromatic.
               7. Leaves glabrous.
                  8. Leaves serrate.
                     9. Leaves prominently 3-veined; receptacle not elongated ..... 51. *Flaveria*
                     9. Leaves not 3-veined, receptacle elongated at maturity ..... 34. *Spilanthes*
                  8. Leaves entire.
                     9. Heads clustered; ray flowers only one, not conspicuous ..... 51. *Flaveria*
                     9. Heads solitary; ray flowers several, conspicuous ..... 42. *Coreopsis*
               7. Leaves pubescent.
                  8. Rays yellow.
                     9. Receptacle elongated at maturity ..... 34. *Spilanthes*
                     9. Receptacle not elongated.
                        10. Ray flowers only one; heads clustered ..... 51. *Flaveria*
                        10. Ray flowers more than one; heads not clustered.
                           11. Rays more than 6; heads more than 1 cm. in di. on peduncles more than 6 cm. long; involucre of many bracts, the outer spreading ..... 39. *Helianthus*
                           11. Rays 4-6; heads less than 1 cm. in di. on peduncles less than 6 cm. long; involucre of 4 appressed bracts ..... 41. *Calyptocarpus*
                  8. Rays white or cream colored.
                     9. Rays 4-6, conspicuously 3-lobed; leaves ovate to lanceolate.

10. Rays cream colored; heads on peduncles over 6 cm. long; leaves deeply serrate or incised ..... 45. *Tridax*
10. Rays white; heads on peduncles less than 6 cm. long; leaves serrate ..... 46. *Galinsoga*

9. Rays numerous, over 6 in number; leaves elliptic ..... 32. *Eclipta*

2. Leaves alternate or basal.
3. Leaves decurrent forming a winged stem.
4. Rays white ..... 40. *Verbesina*
4. Rays yellow ..... 47. *Helenium*

3. Leaves not decurrent; rays white, yellow, pink, or purple.
4. Main leaves basal, stem leaves if present greatly and suddenly reduced in size.
5. Rays white, pink or purple but not yellow.
6. All leaves basal; scape leafless; heads solitary ..... 58. *Chaptalia*
6. Stem leaves present but much reduced and only few in number; heads not solitary, corymbose ..... 23. *Erigeron*

5. Rays yellow.
6. Leaves deeply lobed or lyrate pinnatifid; disk flowers sterile ..... 30. *Berlandiera*
6. Leaves not lobed or pinnatifid; disk flowers fertile.
7. At least some of the stem leaves toothed; leaves spatulate to linear; pappus of several awn-tipped scales ..... 47. *Helenium*
7. Leaves not toothed, entire, linear to lanceolate; pappus capillary or of two erect awns.
8. Pappus of 2 erect awns; disk flowers dark purple; heads solitary ..... 42. *Coreopsis*
8. Pappus capillary; disk flowers yellow; heads not solitary.
9. Plants with white silky pubescence; heads in corymbs ..... 17. *Chrysopsis*
9. Plants glabrous or if pubescent not with white silky hairs; heads in elongated spikes or racemes ..... 18. *Solidago*

4. Stem leaves present.
5. Pappus capillary.
6. Rays white, purple, blue or pink but not yellow.
7. Rays white, 4 or 5, rarely 7 or 8; bracts of the involucre obtuse and leathery ..... 21. *Seriocarpus*
7. Rays numerous; bracts not leathery.
8. Bracts of the involucre in several series; rays white or colored, conspicuous; heads on leafy or scaly peduncles ..... 22. *Aster*

8. Bracts of the involucre in one to three series; heads on naked peduncles.
   9. Heads few; scape little branching, the heads terminal on these branches; ligules numerous (30 to 100), white, pink or violet ..... 23. *Erigeron*
   9. Heads many, panicled; ligules inconspicuous, few (less than 30); flowers whitish ..... 24. *Leptilon*

6. Rays yellow.
   7. Leaves pinnately divided ..... 56. *Senecio*
   7. Leaves not pinnately divided.
      8. Heads small, less than 1 cm. wide; plants glabrous or pubescent but pubescence not white silky nor glandular.
         9. Leaves small, filiform; heads in a flat-topped corymb ..... 19. *Euthamia*
         9. Leaves not filiform; heads in elongated spikes or racemes or in open panicles ..... 18. *Solidago*
      8. Heads 1 cm. or more in di. Plants pubescent with white silky or cottony hairs or with glandular hairs, or glabrous.
         9. Plants with glandular sticky hairs throughout and a camphor-like odor ..... 15. *Heterotheca*
         9. Plants with white silky hairs or white cottony hairs (at least at base of the plant), or glabrous, not aromatic ..... 17. *Chrysopsis*

5. Pappus of awns, scales, or absent, but not capillary.
   6. Leaves glabrous.
      7. Rays yellow; bracts of the involucre spreading.
         8. Leaves short, linear; sessile, entire, punctate.
            9. Heads chaffy; pappus of several scales not awn-tipped; bracts in several series ..... 44. *Actinospermum*
            9. Heads not chaffy; pappus of several silvery awn-tipped scales; bracts in one to two series ..... 47. *Helenium*
         8. Lower leaves long spatulate or elliptic, serrate and narrowed to a winged petiole ..... 47. *Helenium*
      7. Rays white, purple tinged, bracts of the involucre appressed; leaves small, few, distant, elliptic, sessile, entire ..... 20. *Boltonia*
   6. Leaves pubescent.
      7. Rays red with yellow tips or sometimes all yellow; pappus of silvery awned scales; chaff filiform; lobes of disk flowers long acuminate ..... 48. *Gaillardia*

7. Rays yellow or white; pappus not of silvery awned scales; chaff not filiform; lobes of disk flowers not long acuminate.
   8. Leaves merely serrate.
      9. Low prostrate plants with hispid ovate or deltoid leaves; receptacle not elongated ..... 39. *Helianthus*
      9. Erect plants; leaves oval to elliptic; receptacle elongate ..... 35. *Rudbeckia*
   8. Leaves lobed or pinnatifid.
      9. Leaves 3-5 shallowly lobed, ovate in outline; disk flowers fertile; tall woody shrubs ..... 38. *Tithonia*
      9. Leaves pinnatifid or bipinnatifid; disk flowers sterile.
         10. Leaves oblanceolate in outline; rays yellow, conspicuous ..... 30. *Berlandiera*
         10. Leaves elliptic to ovate in outline; rays white, inconspicuous ..... 31. *Parthenium*

Subfamily CICHORIEAE

1. Leaves absent or mere scales; stems rush-like; ligules rose color ..... 59. *Lygodesma*
1. Leaves present; stems not rush-like; ligules not rose color.
   2. Main leaves basal, stem leaves only two or three and much reduced; leaves pubescent with prominent long, soft, silky hairs; flowers bright yellow ..... 60. *Hieracium*
   2. Stem leaves present; leaves glabrous or may be hirsute on midrib below; flowers blue, pale yellow or white.
      3. Heads not in corymbs; peduncles with scale-like bracts ..... 61. *Lactuca*
      3. Heads in corymbs; peduncles naked ..... 62. *Sonchus*

DESCRIPTIONS OF THE SPECIES

Subfamily Ambrosieae

1. Ambrosia L.

Gk. *ambrosia,* food of the gods, conferring immortality.

1. Plants erect, annual; leaves alternate ..... 1. *A. elatoir*
1. Plants prostrate, perennial; leaves opposite ..... 2. *A. hispida*

1. *A. elatoir* L., Sp. Pl. 987. 1753. SHORT RAGWEED, BITTERWEED.
Lat. *elatoir,* taller *A. artemisiifolia* L.
Var. *elatoir* (L.) Des.

Tall, annual, coarse, aromatic, monoecious herbs with much branched, pubescent stems; leaves alternate, petioled, pinnatifid or bipinnatifid, lobed or incised, with short hairs and dark green above, and longer hairs and paler below; general outline of leaf almost deltoid with the lower pinnae longest, the lobes lanceolate to almost elliptic, all lobes acute.

Heads unisexual; the staminate heads in long racemes at ends of the branches, not showy, small, greenish, drooping, about 3 mm. wide, the bracts united forming a 5-12 lobed saucer-shaped involucre; each head with many staminate flowers and each flower with a yellow corolla with 5 acuminate lobes and 5 stamens, the anthers not united as in the other two subfamilies; pappus absent. Pistillate heads below the staminate heads, clustered in the axils of the upper leaves, very small, sessile, one-flowered, corolla absent, pappus absent, involucre nut-like, erect, top-shaped, 3-5 mm. long, bearing a minute beak and about 6 minute tubercules or spines near the apex forming a ring around the top; achene inclosed in the nut-shaped involucre.

The flowers are unusual in several respects: the anthers are not united, the pistillate head has only one flower which has no corolla, the involucre is hard, the bracts are completely united and inclose the achene.

A common, conspicuous, ill-smelling weed found along roadsides, abandoned fields, etc. In lower Dade County ragweeds often form acres of solid growth. This species is most responsible for causing hayfever. (See the discussion on hayfever plants.) Plants can be

found in flower any time of the year, but they are at their best in late spring and throughout the summer. Found throughout the United States and Canada, Bermuda, Bahamas, Cuba, Jamaica. [Plate II, Fig. A.]

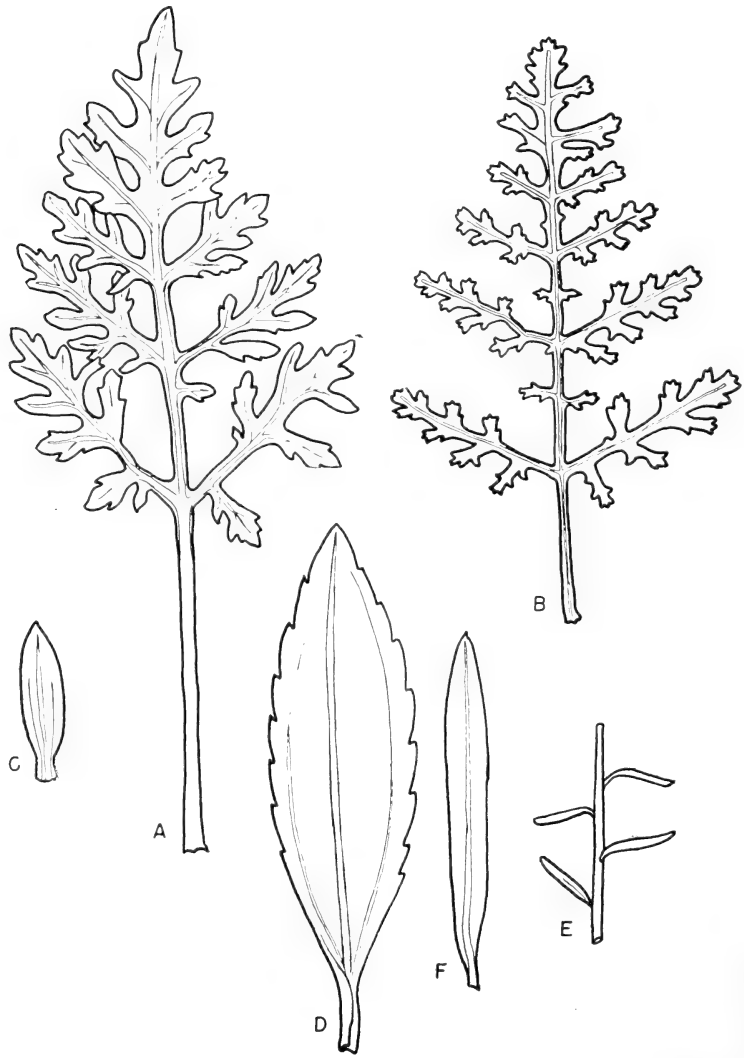

Plate II. A. *Ambrosia elatoir.* B. *Ambrosia hispida.* C. *Iva imbricata.* D. *Iva frutescens.* E. *Iva microcephala.* F. *Vernonia Blodgettii.*

2. *A. hispida* Pursh, Fl. Am. Sept. Suppl. 743, 1814. BEACH RAGWEED.
Lat. *hispida*, spiny, shaggy, rough.

Prostrate and creeping, perennial, aromatic, monoecious plants with long semi-woody pubescent stems; leaves opposite, clasping, petioled, thick light green, white hairy, tripinnatifid, ovate in outline.

Heads unisexual; the staminate heads in upright spike-like racemes, heads short peduncled; involucre irregularly lobed, up to 6 mm. wide and 3 mm. high, cup-like but ovoid or elliptic in outline, several-flowered; staminate flowers with a tubular corolla and 5 stamens, the anthers not united, pappus absent. Pistillate heads solitary, one-flowered, sessile, borne below the staminate heads, surrounded by 2-5 leaves, involucre nut-like, up to 5 mm. high, pubescent, short-beaked and with 1-5 unequal, minute conic spines; corolla absent, pappus absent; achene inclosed in the nut-like involucre.

A conspicuous plant with its light colored, white hairy, much dissected leaves and creeping habit, often forming mats on sand dunes, beaches, and rocky shores in southern Florida and the Keys. Not too common in the Miami area but rather abundant on the lower Keys, especially Key West. Bahamas, Cuba, Dominican Republic, Haiti, Mexico, Yucatan, South America. In Puerto Rico planted as a ground cover. [Plate II, Fig. B.]

2. IVA L.

Named after *Ajuga iva*, from its similar color and odor.

1. Perennial; heads over 3 mm. high, peduncled.
   2. Leaves glabrous, entire or with only a few teeth; bracts of the involucre 6 (to 9), imbricated ..... 1. *I. imbricata*
   2. Leaves pubescent, definitely serrate; bracts of the involucre 4 or 5, not imbricated ..... 2. *I. frutescens*
1. Annual; heads 2-3 mm. high, sessile ..... 3. *I. microcephala*

1. *I. imbricata* Walt., Fl. Carol. 232. 1788. BEACH ELDER.
Lat. *imbricare*, to tile, edges overlapping, referring to the imbricated bracts.

Low sprawling, shrubby plants with glabrous, striate, much branched stems, woody below; leaves aromatic, opposite or alter-

nate, thick and succulent, entire or with a few teeth, elliptic to linear or occasionally lanceolate, up to 5 or 6 cm. long and 2 cm. wide, sessile or very short-petioled, glabrous, with one main vein and 2 obscure lateral veins, apiculate.

Heads produced on the upper part of the stems, solitary, in axils of leaf-like bracts, greenish, drooping, short-peduncled, 5-7 mm. high and about 4 mm. in di.; involucre 4 mm. high, bracts 6 or up to 9, in two rows, the outer shorter than the inner; heads perfect but the flowers unisexual, the pistillate marginal, the staminate in the center; each flower subtended by a bract (chaff); pistillate flowers 2 to 4, corolla reduced to a very short obscure tube; staminate flowers about 10, with a tubular corolla and 5 stamens, the anthers not united; pappus absent.

This species of beach elder with its light green shiny thick leaves is a characteristic plant of the beach flora. It forms large mounds and is very effective in holding sand in place. It can be found on almost any beach, sand dune, or rocky shore from the Sand Keys off Key West to Virginia on the Atlantic and west to Louisiana on the Gulf. Also Bahamas and Cuba. [Plate II, Fig. C.]

2. *I. frutescens* L., Sp. Pl. 989. 1753. MARSH ELDER.
Lat. *frutex,* of the nature of a shrub.

Similar to the preceding species but differing in the following respects: plants taller; leaves up to 10 cm. long, definitely serrate; leaves and stems pubescent; bracts of the involucre 4 or 5 and in one series, not imbricated. Found mostly in and around salt marshes. Not common in our area. S.E.U.S. west to Texas and north to Virginia. [Plate II, Fig. D.]

3. *I. microcephala* Nutt., In Trans. Am. Phil. Soc. n. s. 7: 346. 1841.
Gk. *mikros,* small; *kephale,* head, referring to the small heads.

Annual, somewhat woody herbs, much branched above, lower part of the plant leafless when plant in flower; stems glabrous or finely pubescent; leaves alternate, sessile, minutely hairy, punctate, entire, numerous, small, linear to filiform, 1-3 cm. long, those of the inflorescence under 1 cm. long.

Heads essentially sessile, drooping, solitary in axils of leaf-like

bracts, 2 mm. high and 2-3 mm. wide; bracts 4-5, punctate; heads 6-flowered, each flower subtended by a bract (chaff), staminate and pistillate flowers 3 each; corolla of the staminate flower with 5 small lobes, anthers 5, not united; corolla of the pistillate flower reduced to a minute tube with no lobes; pappus absent.

Inconspicuous plants with slender stems and small leaves and heads, growing in marl prairies and glades south of Miami. Recently collected on the University of Miami campus, the seeds evidently brought in with the marl soil. Ranging from Florida to South Carolina. [Plate II, Fig. E.]

Subfamily Astereae

3. Vernonia L.

Named for William Vernon, early English botanist who traveled in America.

1. *V. Blodgettii* Small, Fl. S.E.U.S., 1160. 1903. IRONWEED.
Named for Dr. John L. Blodgett, physician, surgeon and botanist living in Key West from 1838-1853.

Slender plants branched above; stems sometimes slightly woody at the base, sparingly hairy; leaves alternate, sessile or very short-petioled, entire or sometimes minutely serrate, undulate or revolute, linear, up to 8 cm. long, seldom more than 5 mm. wide, becoming progressively smaller toward the inflorescence, glabrous or lower surface with a few minute white hairs.

Heads discoid, showy, few-flowered; bracts of the involucre imbricated in several series, the outer shorter, occasionally red or purplish, especially the margins and acute tips of the outer bracts; flowers deep red or purple, lobes of the corolla reflexed; pappus capillary, a tawny color sometimes tinged with purple.

Attractive plants seldom over 2 feet high, with narrow leaves, long internodes, and showy red or purple heads. Found mostly in low pinelands, wet prairies and glades, where the soil is not too wet nor too dry, occasionally in dry pinelands and along roadsides. Endemic to south Florida and the pinelands of the lower Keys. [Plate II, Fig. F.]

4. Seneciodes Post & Kuntze

Name from *Senecio* and *eidos,* like, apparently resembling some species of *Senecio.*

1. S. *cinera* (L.) Kuntze, Lex. Gen. Phan. 515. 1904.
Lat. *cinereus,* ash color. *Vernonia cinera* (L.) Less.

Herbaceous plants little branched below but branched above in a corymb; stems grooved, pubescent; leaves alternate, pubescent with short ash-colored hairs, short-petioled or blades reduced to a winged petiole, entire or serrate, the teeth few and rather irregular, mostly ovate to obovate, but sometimes spatulate or lanceolate, up to 5 cm. long, becoming smaller on upper part of the plant.

Heads discoid; bracts of the involucre in several series, long-pointed, often with reddish or purplish tips, pubescent, reflexed after maturity; flowers lilac to white; pappus double, the outer series short and scale-like and inconspicuous, inner series capillary and much longer.

A more or less weedy plant 1 to 2 feet tall, native to Asia but found throughout South Florida, the Keys, Cuba and the West Indies, Central and South America. Originally collected at the Subtropical Experiment Station near Homestead, Royal Palm State Park, and Richmond Campus, but apparently spreading northward into Coconut Grove where it is becoming a weed in lawns and gardens and along roadsides.

In Java the young plants are cooked and eaten as vegetables; also the natives use the plant in medicine as a poultice for headaches, wounds, and ringworms; internally used for coughs and colic. [Plate III, Fig. E.]

5. Elephantopus L.

Gk. *elephantos,* elephant, *podos,* foot, referring to the large basal leaves.

1. *E. tomentosus* L., Sp. Pl. 814. 1753. elephant's foot.
Lat. *tomentosus,* wool.

Perennial herbs with basal leaves forming a rosette and a long central scape sparingly branched above; basal leaves broad elliptic to oval, obovate, or oblanceolate, up to 2 dm. long and 8 cm. wide, thick white tomentose, sessile or short-petioled, crenate to dentate-

serrate; scape devoid of leaves, or more often with a few much reduced, sessile, clasping, lanceolate leaves.

Heads discoid, clustered, sessile, and surrounded by an involucre of 3 leaf-like bracts; involucre of the individual heads with 8 bracts,

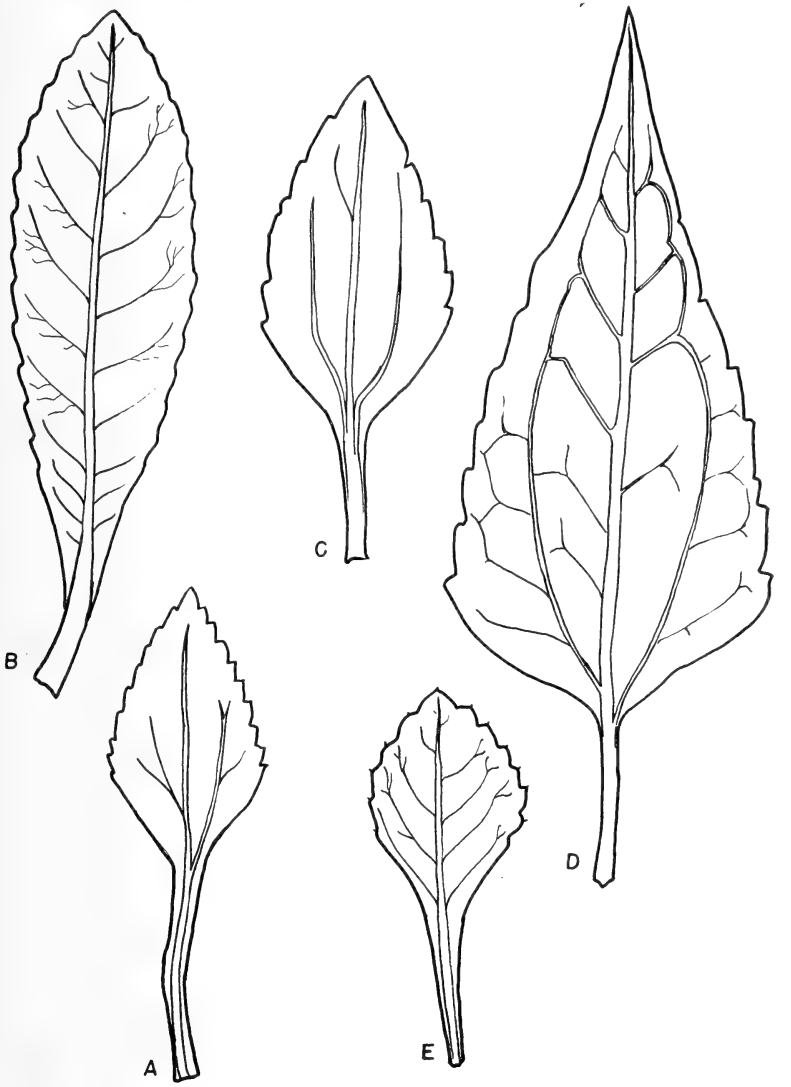

Plate III. A. *Ageratum littorale.* B. *Elephantopus tomentosus.* C. *Osmia frustrata.* D. *Osmia odorata.* E. *Seneciodes cinera.*

the outer shorter; heads 3-5 flowered, the flowers split on one side for a short distance, corolla deeply five-lobed, purplish; pappus of capillary bristles broadened at the base.

Conspicuous plants with large basal leaves lying almost flat on the ground and the scape up to 2 feet high with many sessile heads clustered in several groups, each group subtended by 3 large bracts. Found in acid, sandy pineland or along roadsides where the soil is only slightly acid; in northern Dade County and Broward County. The southern limit of its range seems to be just north of Miami. S.E.U.S. north to Virginia and west to Texas and Arkansas. Cultivated in Hawaii. [Plate III, Fig. B.]

6. Ageratum L.

Gk. *a*, without, *geras*, old age.

1. *A. littorale* A. Gray, in Proc. Am. Acad. 16: 78. 1881.
Lat. *litoralis*, shore.

Low, much branched plants; leaves opposite, petioled, glabrous, thick and succulent, light green and shiny, dentate, ovate, blade up to 5 cm. long.

Heads clustered in tight corymbs which are on rather long stalks; heads discoid, peduncled; receptacle dome-shaped; involucre 4 mm. high, bracts narrow, acute, imbricated in several series, small bracts at base of involucre; corolla lobes blue, erect; pappus reduced to a crown, so minute that it appears to be absent.

Low growing plants only about 1 foot high and often hidden by the surrounding vegetation and noticed only because of the bright blue heads which project above the other plants. The leaves are thick and light green and shiny. Greatly resembling *Conoclinum* but separated from that genus by the pappus which is capillary in *Conoclinum* and crown-like in *Ageratum*. Found only on sandy and rocky shores of the Keys, especially Key West, and Cape Sable. Moldenke (1944) collected a white flowered form *(A. littorale f. album)* in dry soil on Big Pine Key in 1930. [Plate III, Fig. A.]

7. Osmia Sch. Bip.

Gk. *osme*, a smell, referring to the odor of the plants.

1. Branches produced more or less horizontally; flowers white; vine-like shrub ..... 1. *O. odorata*

1. Branches produced more or less vertically; flowers blue; herbaceous plants ..... 2. *O. frustrata*

1. *O. odorata* (L.) Sch. Bip., in Pollichia 22-24: 256. 1886. BITTER BUSH.

Lat. *odorus,* fragrant. *Eupatorium odoratum* L.
Eupatorium conyzoides Vahl.

A much branched, aromatic, vine-like shrub; branches borne more or less horizontally, the leaves and branches 4-ranked; stems pubescent; leaves opposite, ovate to lanceolate, acuminate, coarsely and irregularly serrate, pubescent, 3-veined, petioled.

Heads discoid, up to 10 mm. high; bracts of the involucre papery or leathery, erose or ciliated, imbricated in more than 3 series, the outer bracts broad and short, the inner ones long and narrow, whitish-green, the tips often purple or lilac color; flowers white or sometimes pale lilac, mostly 5 mm. long; pappus capillary.

A tropical plant often forming thickets in and around hammocks in the Cape Sable region and on Key Largo and possibly on some of the other Keys. The branches are long and vine-like, often climbing over other vegetation especially on Cape Sable where the plants are found climbing high into the trees. The leaves when crushed give off a characteristic odor. *Osmia* is separated from *Eupatorium* mainly by the length of the involucre which is more than 6 mm. long and often up to 10 mm. in length in *Osmia,* and less than 6 mm. high in *Eupatorium.* Occasionally some plants will be found on the mainland north of Cape Sable especially on the road to Royal Palm State Park, but these plants probably will not survive for any length of time for they are easily killed by frost. Recently collected in a thicket along a canal near the University of Miami, Coral Gables. Found in Cuba and throughout the West Indies, Central America and South America. [Plate III, Fig. D.]

2. *O. frustrata* (B. L. Robinson) Small, in Fl. Florida Keys, 147. 1913.

Lat. *frustrator,* a deceiver. *Eupatorium frustratum* L.
Eupatorium heteroclinum Chapm.

Brittle, much branched herbs, somewhat woody; stems green, grooved, pubescent, branches borne more or less vertically; leaves opposite, ovate to lanceolate, mostly obtuse, dentate, up to 6 cm. long and 3 cm. wide, petioled, 3-veined, pubescent.

Heads discoid; involucre of several series of imbricated bracts, 5-8 mm. high; bracts all appressed, greenish to greenish-white, the tips often slightly colored; flowers purplish-blue, 4 mm. long; pappus capillary.

This species has a very restricted range and is nowhere very common. It is endemic to south Florida and is found mostly in low places around mangrove hammocks on Cape Sable, Key Largo, 10,000 Islands, and reported by Davis (1942) from the Florida Sand Keys. The blue flowers, low growth (1-2 feet), and ovate leaves resemble the common *Conoclinum*. The plants have a very spicy odor, more so than *O. odorata*. The stems and leaves are very brittle and break off very easily if the plants are handled roughly. [Plate III, Fig. C.]

8. Eupatorium L.

Named for Mithridates Eupator, King of Pontos, said by Pliny to have used one of the species in medicine.

Herbs or shrubs; leaves mostly opposite but occasionally alternate, both conditions occurring on the same plant; leaves simple or compound, the latter having very narrow divisions and often twice compound, none of our species with whorled leaves; heads mostly in flat-topped corymbs, discoid, less than 6 mm. high; flowers white to greenish or cream color or pinkish-white; pappus capillary.

1. Leaves compound, at least on the lower part of the plant and on new shoots; the leaves, or divisions of the compound leaves, filiform or narrowly linear.
   2. Leaves or divisions of the compound leaves filiform or thread-like.
      3. Inflorescence branches recurved; heads usually on one side of the branches; plants glabrous ..... 1. *E. leptophyllum*
      3. Inflorescence branches not recurved; heads on all sides of the branches; plants pubescent ..... 2. *E. capillifolium*
   2. Upper leaves linear-lanceolate, not filiform, simple; lower leaves divided ..... 3. *E. compositaefolium*

1. Leaves broad, over 3 mm. wide, entire, toothed or serrate, but never compound.
   2. At least some of the leaves deeply incised or almost pinnatifid ..... 4. *E. Eugenei*
   2. Leaf margins toothed but never deeply incised.
      3. Leaf blades sessile.

4. Leaves drooping ..... 5. *E. recurvans*
4. Leaves not drooping ..... 6. *E. hyssopifolium*

3. Leaf blades definitely petioled.
4. Leaves thick and fleshy; leaf margins crenate to dentate ..... 7. *E. mikanioides*
4. Leaves not thick nor fleshy; leaf margins serrate.
5. Leaves glabrous ..... 8. *E. juncundum*
5. Leaves pubescent.
6. Leaves lanceolate, coarsely serrate, acute to acuminate ..... 9. *E. serotinum*
6. Leaves ovate to deltoid, sparingly serrate, obtuse to mucronate ..... 10. *E. villosum*

1. *E. leptophyllum* DC., Prodr. 5: 176. 1836. FENNEL.

Gk. *leptos,* thread, *phyllon,* leaf.

Usually tall, weedy, aromatic annuals, woody at the base, glabrous throughout but occasionally the stems and petioles of young plants may have a few white hairs; leaves opposite, often alternate above, once or twice compound, the divisions narrow and filiform, lower leaves petioled, upper leaves sessile and often simple; leaves often fascicled at each node.

Heads numerous, borne on one side of the branches, the branches recurving; heads short-petioled, few-flowered (3-6); bracts long acuminate, upper part of bracts white; flowers 2-3 mm. long.

This and the following species are two common weeds. They can be easily identified by the numerous small heads produced all along the branches, and by the numerous, much divided, narrow leaves. Both species flower mostly in the fall months. *E. leptophyllum* is found in fields, roadsides, stream banks, everglades, and around ponds, mostly where the soil is moist. S.E.U.S. to South Carolina and west to Miss. Bahamas, Cuba. [Plate IV, Fig. A.]

2. *E. capillifolium* (Lam.) Small, in Mem. Torr. Bot. Club 5: 311. 1894. DOG-FENNEL.

Lat. *capillus,* hair, *folium,* leaf.

Plants resembling *E. leptophyllum* but differing in the following respects: plants pubescent, the young shoots often having a dense mat of white hairs on the main axis; leaf divisions usually a little broader and not quite as thread-like; heads produced on all sides of the inflorescence branches, the branches not recurved.

In fields, roadsides, around hammocks, etc., usually in drier places than *E. leptophyllum.* E.U.S. west to Texas and north to Mass. Bermuda, Bahamas, Cuba. [Plate IV, Fig. B.]

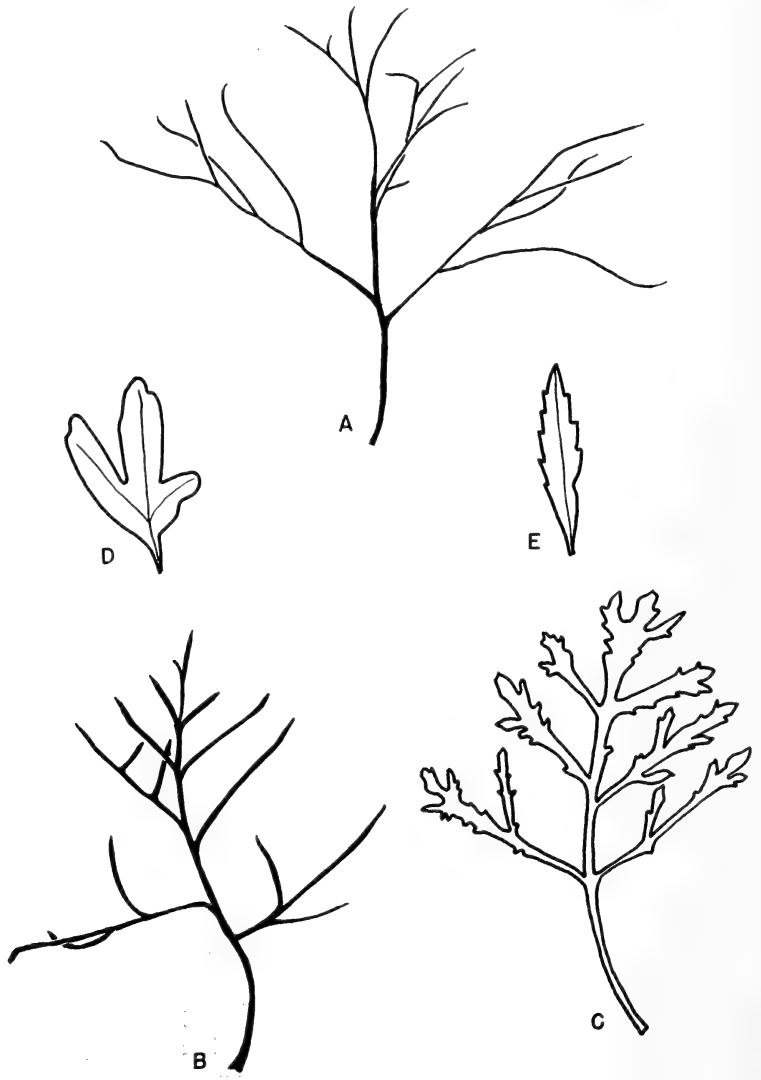

Plate IV. A. *Eupatorium leptophyllum.* B. *Eupatorium capillifolium.* C. *Eupatorium compositaefolium.* D. *Eupatorium Eugenei.* E. *Eupatorium hyssopifolium.*

3. *E. compositaefolium* Walt., Fl. Carol. 199. 1788. THOROUGHWORT.

Lat. *compositus*, referring to the compound leaves.

Stems somewhat woody, pubescent, grooved; leaves opposite or alternate, lower ones definitely compound and petioled, upper ones mostly simple, occasionally irregularly lobed, sessile; leaves punctate and somewhat viscid, clustered at the nodes, definitely wider than the two preceding species.

Heads numerous, 4-6 flowered, on upright branches; bracts punctate and viscid, pubescent; some of the bracts with white scarious margins and mucronate tips; flowers 3 mm. long, white to cream-colored.

Mature plants usually found with all the lower compound leaves dried and fallen off, and thus all the leaves remaining on the plant are simple and clustered at the nodes. This species is not too common; it is found in dry pinelands. S.E.U.S. west to Texas and north to North Carolina. [Plate IV, Fig. C.]

4. *E. Eugenei* Small, Fl. S.E.U.S. 1167. 1903. THOROUGHWORT.

Herbs often woody near the base; leaves opposite or alternate, deeply incised, 3-5 lobed, or almost pinnatifid, or simple and not lobed, linear or lanceolate, usually under 4 cm. long, punctate, margins entire or mostly coarsely and irregularly serrate.

Inflorescence branches upright, not plumose; heads clustered at the ends of the branches forming a rather compact inflorescence; bracts few in number; not punctate; heads abont 8-flowered; flowers 2-5 mm. long.

Not common. Pinelands. S.E.U.S. from Florida to Alabama. [Plate IV, Fig. D.]

5. *E. recurvans* Small, Fl. S.E.U.S. 1167. 1903. THOROUGHWORT.

Lat. *re*, back, *curvare*, to bend.

Stems mostly simple, branching in the inflorescence into a flat-topped corymb; stems white hairy; leaves small, less than 5 cm. long, reflexed downward so they appear to be drooping, somewhat closed or folded in along the midrib, linear to lanceolate, rather coarsely and sparingly toothed, punctate, sessile.

Heads in clusters of 3-7; heads 4-5 mm. high, about 5-flowered; bracts green with white tips; flowers 3 mm. long, white to pinkish.

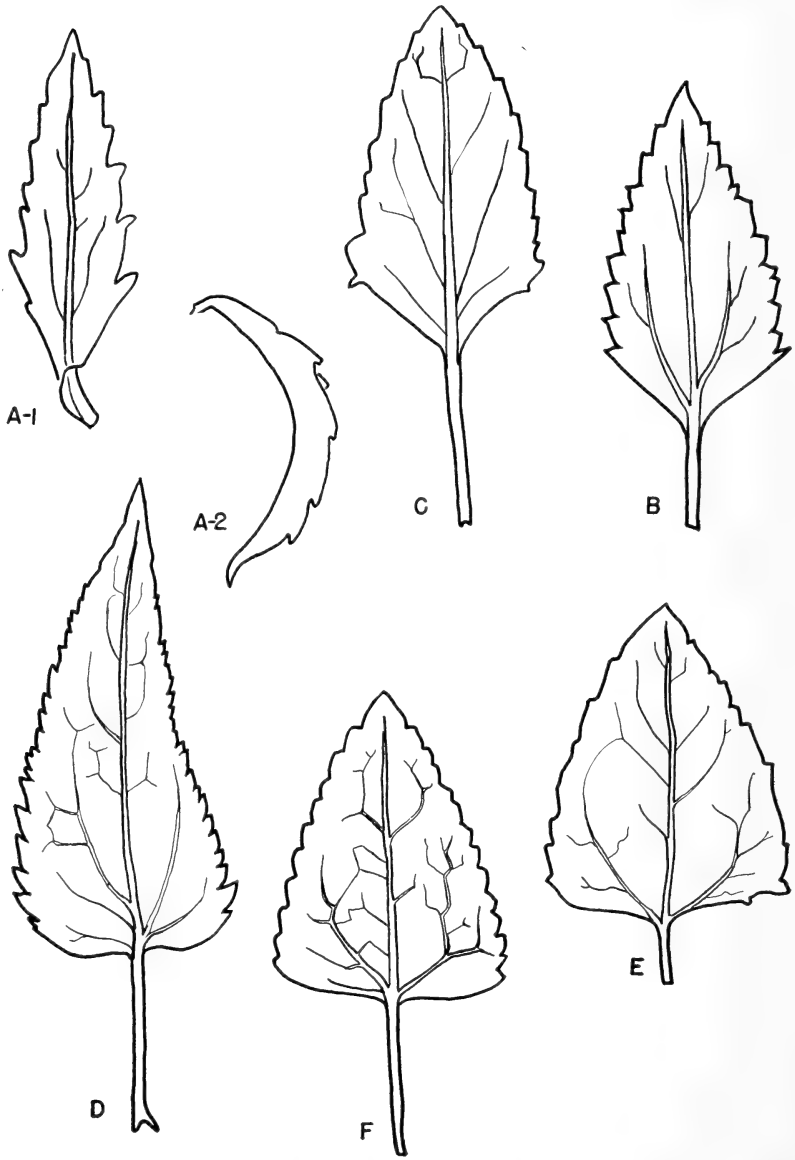

Plate V. A-1 and A-2. *Eupatorium recurvans.* B. *Eupatorium juncundum.* C. *Eupatorium mikanioides.* D. *Eupatorium serotinum.* E. *Eupatorium villosum.* F. *Conoclinum coelestinum.*

The distinguishing feature of this species is the drooping or reflexed habit of the leaves. Found in low but rarely wet pinelands in northern Dade County and Broward County where the soil is acid. S.E.U.S. Florida to Miss. and Virginia. [Plate V, Fig. A.]

6. *E. hyssopifolium* L., Sp. Pl. 836. 1753. THOROUGHWORT.
Hyssop, a mint, Lat. *folium,* leaf.

Stems hairy; leaves alternate or opposite, sessile or essentially so, coarsely serrate but never incised or compound, linear, 2-6 cm. long but mostly 3 cm. long, up to 1 cm. wide, punctate. Inflorescence flat-topped; bracts obtuse; flowers 3.5 mm. long.

In pinelands. Not common. E.U.S. west to Texas and north to Mass. [Plate IV, Fig. E.]

7. *E. mikanioides* Chapm., Fl. S.U.S. 195. 1860. THOROUGHWORT.
Named after some species of *Mikania.*

Stems little if at all branching except in the inflorescence, glabrous in age but tomentose when young; leaves opposite, tending to stand at right angles to the stem, petioled, crenate to dentate, obtuse, thick and fleshy, distant, up to 6 cm. long, ovate to deltoid.

Heads about 5-flowered; bracts soft white pubescent, linear, acute, white with green margins; flowers white but sometimes pinkish, about 4 mm. long.

A characteristic herb of wet prairies, salt marshes and the everglades where the soil is sandy or marly and wet. Easily identified by the light colored, thick leaves which stand at right angles to the stem. Endemic to Florida as far north as St. Marks Refuge. [Plate V, Fig. C.]

8. *E. juncundum* Greene, Pittonia, 3: 180. 1901. THOROUGHWORT.
Lat. *jucundus,* agreeable, from the odor of the flowers.

Stems minutely hairy, somewhat woody at the base; leaves opposite, petioled, coarsely dentate to serrate, glabrous, acute or obtuse, ovate-deltoid, 5-8 cm. long.

Involucre of one series of bracts with 2 or 3 small bracts at the base; bracts linear, short-pointed; heads with 15 to 20 flowers; flowers about 5 mm. long, slightly fragrant.

In dry pinelands south of Miami and in and around oak hammocks of the Redlands area. Not common; probably more characteristic of the acid pinelands north of our area. Ranges over most of Florida. [Plate V, Fig. B.]

9. *E. serotinum* Michx., Fl. Bor. Am. 2: 100. 1803. THOROUGHWORT.

Lat. *serotinus,* late ripening, probably referring to the late flowering or ripening of the seeds.

Usually tall shrubby plants up to 25 dm. tall but more often much smaller and less woody and shrubby; stem pubescent; leaves opposite or alternate, long-petioled, lanceolate to ovate-lanceolate, acute or acuminate, 3-veined, pubescent, serrate, often coarsely toothed, 5 to 20 cm. long.

Heads 5 mm. long or less; bracts white-tipped, pubescent, broadest above the middle; heads 10-15 flowered, flowers only 3 mm. long.

A common shrub or sub-shrub with long, lanceolate, coarsely toothed leaves; found mostly in low moist places such as the everglades, along stream and canal banks, wet prairies, salt flats, edges of mangrove hammocks; rarely in pinelands. E.U.S. west to Texas, Iowa and Kansas and north to Mass. Also northern Mexico. [Plate V, Fig. D.]

10. *E. villosum* Sw., Prod. Veg. Ind. Occ. 111. 1788. THOROUGHWORT.

Lat. *villosus,* hairy.

Usually tall woody shrubs with a mint-like odor; stems glabrous below, villous above; leaves opposite, ovate to deltoid or rarely ovate-lanceolate, short-petioled, soft pubescent, obtuse with a mucronate tip, sparingly dentate, 2-6 cm. long or sometimes up to 10 cm. long, slightly revolute and occasionally appearing entire or undulate.

Heads in terminal corymbs with about 5 heads clustered in a group; bracts pubescent, sometimes red-tipped; heads few-flowered, white or pinkish, flowers 3 mm. long.

A tropical shrub found in and around hammocks and often in the pinelands as a pioneer shrub for the hammocks. The rather small, ovate leaves and mint-like odor characterize this species. Found

in south Florida and the Keys. Bahamas, Cuba, Dominican Republic and probably the lower Antilles. [Plate V, Fig. E.]

9. Conoclinum DC.

Lat. *conus,* cone, *clinus,* receptacle, referring to the conical receptacle.

1. *C. coelestinum* (L.) DC., Prod. 5: 135. 1836. MIST FLOWER.
Lat. *coelestinus,* sky blue. *Eupatorium coelestinum* L. *Conoclinum dichotonum* Chapm.

Herbaceous plants with pubescent often purple stems; leaves opposite, petioled, deltoid to ovate, dark green or reddish-purple, crenate, up to 6 or 7 cm. long, pubescent.

Heads discoid in terminal clusters, short-stalked; receptacle conical; bracts acute, pubescent, imbricated in several series; flowers purple-blue; pappus of a few capillary bristles.

An attractive plant with its bright blue or purple-blue flowers and dark green leaves which are often tinged with reddish purple. This species resembles the native and cultivated *Ageratum* but is separated from it by the pappus which in *Conoclinum* is capillary. Found mostly in moist soil in low pinelands, marshes, everglades, wet prairies, sink holes in the Miami pineland, etc. E.U.S. west to Texas and north to Michigan and New Jersey. Cuba. [Plate V, Fig. F.]

10. Carphephorus Cass.

Gk. *karphos,* straw, *phorus,* bearing.

1. *C. corymbosus* (Nutt.) T. & G., Fl. No. Am. 2: 67. 1843. PAINT BRUSH.
Gk. *korumbos,* cluster, referring to the inflorescence.

Herbs with simple stems, branched above; stems pubescent; leaves alternate, entire, thick and succulent, light green, glabrous, acute; lower leaves spatulate, narrowed to a winged petiole or a petiole-like base, up to 15 cm. long; leaves rather suddenly reduced on the lower part of the stem; stem leaves sessile, semi-clasping, ovate to elliptic, obtuse or notched, only 1-3 cm. long.

Heads discoid, 1 cm. in di., clustered in a terminal corymb; involucre campanulate, 8-10 mm. high, imbricated in several series;

bracts green, punctate, thickish, ovate, scarious, tips reflexed and spreading, margins erose; receptacle chaffy; corolla rose-purple; pappus capillary, barbed, a light tawny color in age.

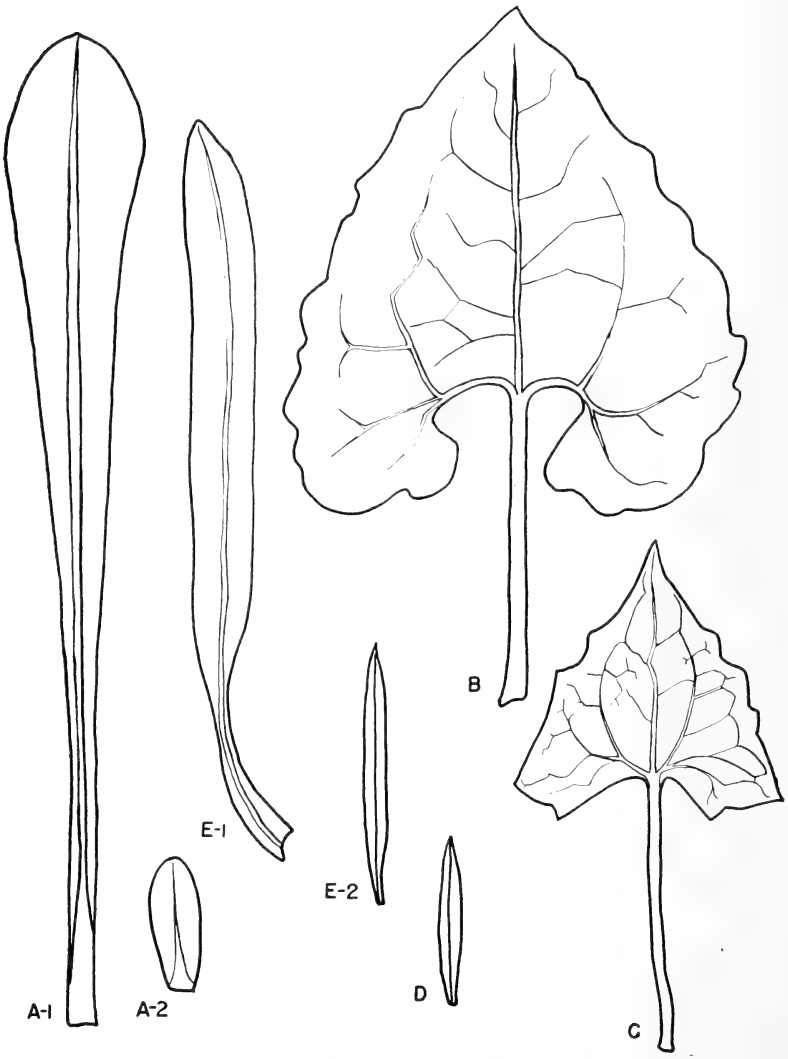

Plate VI. A. *Carphephorus corymbosus;* 1. basal leaf, 2. stem leaf. B. *Mikania cordifolia.* C. *Mikania batatifolia.* D. *Kuhnia Mosieri.* E. *Liatris Chapmanii;* 1. basal leaf, 2. stem leaf.

An attractive plant with large, light colored basal leaves forming a rosette; scape up to 3-4 feet high with much reduced leaves and large heads in a rather tight corymb. The flowers resemble those of *Liatris* and *Trilisa*. Found in acid soil in the sandy pinelands of northern Dade County and above Naples on the West Coast and in the scrub land of Broward County. S.E.U.S. north to North Carolina. [Plate VI, Fig. A.]

11. Mikania Willd.

Named for J. G. Mikan, 1734-1814, professor at the University of Prague.

Herbaceous vines climbing on low herbs, bushes, or trees; glabrous or pubescent; leaves opposite, petioled; heads discoid, in corymbs, produced all along the twining stems, clustered, short-stalked; flowers white or pinkish, fragrant; heads of 4 bracts and 4 flowers; pappus capillary.

1. Plants glabrous or essentially so; leaves 1-6 cm. long, entire, base of leaf hastate ..... 1. *M. batatifolia*
1. Plants densely pubescent; leaves 6-15 cm. long, toothed or lobed; base of leaf cordate ..... 2. *M. cordifolia*

1. *M. batatifolia* DC., Prod. 5: 197. 1836. HEMP VINE.
Haitian, *batata,* the sweet potato *Batatas,* Lat. *folium,* leaf.
Willugbaeya heterophylla Small

Stems angled or ridged with lines; leaves long acuminate or merely acute, hastate at base, sparingly pubescent with short hairs or entirely glabrous, deltoid, entire, usually small, 2-3 cm. long, but may be up to 6 cm. long. Bracts acute or acuminate, pubescent, upper part of bracts white, lower part green; heads in small clusters.

This species of *Mikania* is rather common and can be found in low moist places such as low pinelands, wet prairies, edges of hammocks, along stream and canal banks, everglades, etc., but sometimes found in dry places in the pinelands. It is easily identified by its climbing habit over low vegetation, its deltoid leaves and numerous, fragrant, white or pinkish heads. Southern Florida and the Keys. Bahamas, Cuba. [Plate VI, Fig. C.]

2. *M. cordifolia* (L.) Willd., Sp. Pl. 3, 1746. 1804. HEMP VINE.
Lat. *cordis,* heart, *folium,* leaf. *Willugbaeya cordifolia* Kuntze.

Plants mostly densely pubescent; leaves 6-15 cm. long, toothed or lobed, ovate, cordate at the base, obtuse. Heads clustered, the corymbs larger than the preceding species; bracts obtuse or acute, pubescent.

M. cordifolia is not as common as *M. batatifolia* and is confined mostly to hammocks and thickets in more or less moist places. It is a higher climbing species, climbing over shrubs and trees. Its leaves and flowers are much larger. Southern Florida and the Keys. Cuba and throughout the West Indies, Central America and South America. [Plate VI, Fig. B.]

12. Kuhnia L.

Named for Adam Kuhn of Philadelphia who collected plants for Linnaeus.

1. *K. Mosieri* Small, Man. S.W. Flora, 1329. 1933.
Named for Charles H. Mosier, a naturalist who helped Small in his field work. *K. paniculata* Cass.

Slender herbs, branching sparingly above; stems grooved, finely pubescent; leaves alternate, sessile, glabrous, punctate, thickish, distant, linear, small, less than 3 cm. long, entire, often revolute, mostly reflexed or twisted on the stem and often drooping.

Heads in open corymbs, peduncled, discoid, up to 15 mm. high; involucre cylindric, bracts imbricated in several series, the outer shorter, persistent, becoming reflexed when the achenes are mature, pubescent; flowers white to cream color or yellowish, usually 12 in a head; pappus plumose. This is the only species of this subfamily in which the anthers are not united into a ring around the style, the anthers being easily separated.

More or less inconspicuous plants with tall, wand-like stems, small drooping or twisted leaves borne rather far apart from each other, and many white to yellow narrow heads in an open corymb. Not too common; flowering mostly in late winter and early spring months. In dry pinelands of southern Florida but also reported from the Gainesville area (Murrill, 1945). [Plate VI, Fig. D.]

13. Liatris Schreb.

Derivation of name not known. *Laciniaria* Hill

Erect perennial herbs with naked corms which are globular or

elongated; stems simple or often clustered, bearing the heads on the upper part; leaves numerous, alternate, spirally arranged, narrow, punctate, linear to lanceolate, lower leaves often greatly elongated, upper leaves gradually reduced in size, or suddenly reduced and scale like; heads sessile or stalked, in elongated spikes or racemes, discoid; flowers purple or rose-purple, rarely pink or white; involucre imbricated in several series, bracts scarious-margined and often colored; pappus capillary or minutely plumose.

There are three distinct and common species of blazing stars in our area: *L. chapmanii, L. chlorolepis,* and *L. tenuifolia.* Several other types have been collected but these are puzzling forms and may represent hybrids. *L. gracilis* and *L. laxa* have been reported for this area but the author has not been able to find them.

1. Bracts acute to acuminate, definitely pointed; heads mostly sessile (or very short-peduncled) but always dense, packed closely together ..... 1. *L. Chapmanii*
1. Bracts rounded at the apex, obtuse.
   2. Heads peduncled, the inflorescence a raceme.
      3. Lower leaves linear-lanceolate, gradually reduced in size from the base of the plant to the inflorescence ..... 2. *L. chlorolepis*
      3. Lower leaves grass-like, linear-filiform, very long; leaves suddenly and greatly reduced in size from the base of the plant to the inflorescence ..... 3. *L. tenuifolia*
   2. Heads sessile, the inflorescence a dense spike ..... 4. *L. spicata*

1. *L. Chapmanii* Torr. & Gray, Fl. No. Am. 2: 502. 1843. BLAZING STAR.

Named for Dr. Alvin W. Chapman, 1809-1899, well known southern botanist.

Corm globular; stem thick, rather tall, rarely branched above but often branched at the base, usually striate, tomentose; leaves coming out all around the stem, tending to stand out horizontally, often twisted counter-clockwise, sometimes drooping, sessile, entire, linear, acute, glabrous, often ciliate, sometimes with a few hairs below the middle, punctate, largest near the base of the plant, lower leaves petioled, gradually becoming smaller, bract-like in the inflorescence and merging into the bracts of the involucre.

Heads sessile, packed closely together, mostly 3-4 flowered; involucre bracts acuminate to acute, the tips erect and appressed, linear, glabrous. Flowers usually rose-purple, rarely pink or white.

The first blazing star to come into flower, often as early as late May. Easily identified by the tall, wand-like stem with an elongated spike of many rose-purple heads borne very close together. In both acid and alkaline soil of the pinelands. Florida and Georgia. [Plate VI, Fig. E.]

2. *L. chlorolepis* Small, Man. S.E. Fl. 1333, 1933. BLAZING STAR.
Gk. *chloro,* green, *lepis,* a scale.

Corms root-like, not globular, more or less elongated and branched; stems with soft hairs; lower leaves may be up to 15 cm. long but usually less, narrow, linear or narrowly lanceolate, entire; upper leaves gradually becoming smaller; all leaves sessile, distant, sparingly hairy, ciliate on the margins; occasionally the leaves may be dense and very numerous.

Inflorescence an elongated raceme, the heads peduncled and often divergent, sometimes branching; bracts of the involucre red-margined, sometimes the entire bract is deep red in color; the tips of the bracts obtuse, definitely recurved or spreading, especially noticeable in the unopen buds; heads rather loosely arranged; about 8-flowered.

Easily identified by the tall wand-like stems with peduncled heads standing almost at right angles to the stem. It is strange that *L. chlorolepis* has not been collected from this area before; it is very common in both acid and alkaline pinelands through this area. Small (1933) describes it only from Tampa, and Gaiser (1946) does not recognize it as being different from *L. Garberi.* But it is quite distinct and a very good species. [Plate VII, Fig. A.]

3. *L. tenuifolia* Nutt., Gen. Am. 2: 131. 1818. BLAZING STAR.
Lat. *tenuis,* narrow, *folium,* leaf.

Corm globular; lower leaves clustered and grass-like, usually very long, over 15 cm. and sometimes up to 3-4 dm. long, forming a rosette, narrow, mostly less than 6 mm. wide, entire, glabrous or with a few cilia on the margins; stems from the center of the rosette, glabrous or with a few hairs; the stem leaves suddenly and greatly reduced on the lower part of the stem to mere scale-like leaves only a few mm. in length, the stem appearing naked.

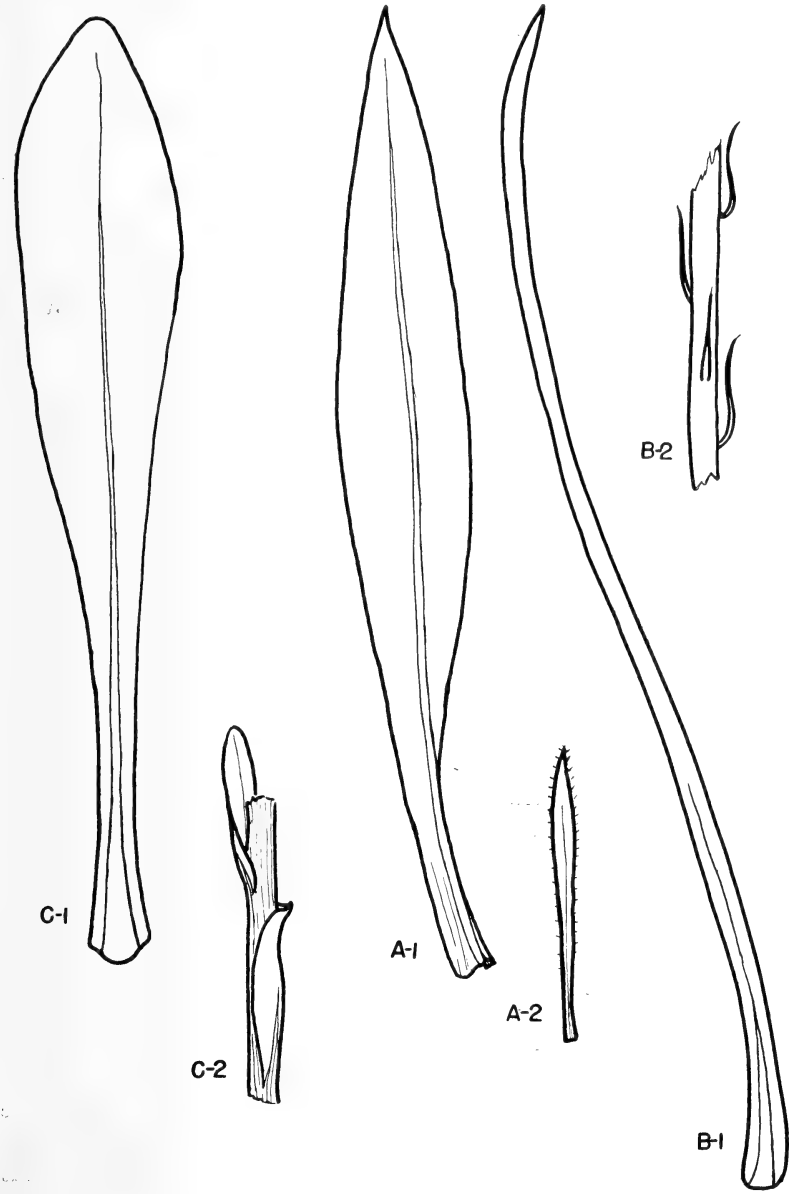

Plate VII. A. *Liatris chlorolepis;* 1. basal leaf, 2. stem leaf. B. *Liatris tenuifolia;* 1. basal leaf, 2. stem leaves. C. *Trilisa odoratissima;* 1. basal leaf, 2. stem leaves.

Heads in racemes, rarely a spike, peduncled, numerous and mostly close together, about 4-flowered; involucre bracts mostly dark red in color, inner bracts erose-margined at the tip; all bracts obtuse.

A common species in the pinelands conspicuous by its large, grass-like clumps and tall wand-like stems with numerous short-stalked heads. S.E.U.S. to North Carolina and Alabama. [Plate VII, Fig. B.]

L. laevigata Nutt., Trans. Amer. Phil. Soc. n.s. 7: 285. 1841, is a species of blazing star which is very close to *L. tenuifolia.* Gaiser (1946) has recognized it as a distinct species ranging from Jacksonville to Big Pine Key, but Robinson (Proc. Amer. Acad. Arts and Sci. xlvii, 201. 1911) recognizes it merely as a variety of *L. tenuifolia* which is probably what it should be. The characters which separate *L. tenuifolia* and *L. laevigata* are presented in the following table.

L. tenuifolia	*L. laevigata*
Plant with scattered hairs on stem.	Plant completely glabrous.
Leaves sparingly ciliate.	Leaves without cilia.
Leaves dull.	Leaves glossy or shiny, coriaceous.
Leaves filiform, 2 mm. wide or less.	Leaves linear, involucre, 2-8 mm. wide.
Corm up to 2 cm. in di.	Corm up to 4 cm. in di.

L. tenuifolia var. *laevigata* (Nutt.) Robinson (if we recognize the plant as a variety instead of a distinct species) is very common in our area, and perhaps most of the *tenuifolia* here belong to this variety.

4. *L. spicata* Willd., Sp. Pl. 1636. 1803. BLAZING STAR.

Lat. *spica,* a spike.

Corm more or less globular; stem glabrous; leaves numerous, glabrous, sessile, entire, long linear, acute, on the lower part of the stem usually quite elongated and grass-like, 20-30 cm. long, 5-8 mm. wide, becoming gradually smaller and narrower to the inflorescence and merging into the bracts that subtend the heads.

Inflorescence a spike, either dense or loosely spicate, the heads sessile and slightly spreading; heads on lower part of the inflorescence conspicuously exceeded by the subtending bracts, but the heads toward the upper part of the inflorescence longer than the

bracts; involucre bracts obtuse, appressed, somewhat sticky, with scarious margins which are almost petaloid and pink or purplish in color; flowers 4 to 10.

Resembling *L. tenuifolia* but the leaves are more gradually reduced upward rather than suddenly, and the majority of the heads are sessile. Collected on Long Pine Key, in Pinelands, Dade County. The typical species usually grows in moist woods, low pinelands, wet prairies, etc. Gaiser (1946) refers our plants to *var. resinosa,* this variety tending to grow in drier places than the typical species. E.U.S. west to La. and north to Canada.

L. gracilis Pursh, Fl. Amer. Sept. 508. 1814. This species has been reported for this area. The plants are completely glabrous or with a few cilia on the margins of the leaves; leaves gradually reduced in size; heads sessile or very short-peduncled and often standing out from the rachis at right angles, distant; heads the smallest of the genus, 7-9 mm. long, 4-8 flowered; bracts obtuse; involucre turbinate.

L. laxa Small, Bull. Torr. Bot. Club. 25; 472. 1898. This species is not recognized by Gaiser (1946). The main differences that separate this species from *L. gracilis* are the following: involucre campanulate, stems densely white hairy.

14. Trilisa Cass.

Trilisa, an anagram of Liatris.

1. *T. odoratissima* (Walt.) Cass., Bull. Soc. Philom. 140. 1818. VANILLA PLANT.

Lat. *odoratus,* sweet smelling, *issimus,* very much.

Plants glabrous throughout; basal leaves large, thick, leathery, somewhat succulent and watery, entire or coarsely serrate, oblanceolate, obovate or elliptic, up to 25 or 30 cm. long, tapering to a winged petiole; stem leaves sessile, clasping, shallowly serrate but the upper ones mostly entire, becoming smaller toward the top of the plant; all leaves alternate and prominently veined.

Scape from the center of the rosette; inflorescence a much branched corymb; heads discoid; involucre imbricated in several series, the bracts subequal, acute, purplish-colored, glandular, the glands sessile, punctate-like, glistening; heads 8-12 flowered, the

flowers about 4 mm. long, rose-purple in color; pappus capillary, rose-purple.

A very attractive plant resembling to a certain extent *Liatris* and *Carphephorus*, especially in the color of the flowers. The basal leaves are large and thick and form a rosette and are supposed to have a vanilla-like odor, especially when dried; some plants, however, have no odor or only a very faint one. Found in acid sandy pinelands and scrub lands of northern Dade County, Broward County, and Collier County above Naples. S.E.U.S. north to Virginia and west to La. [Plate VII, Fig. C.]

15. Heterotheca Cass.

Gk. *heteros*, different, Lat. *theca*, case, referring to the two types of achenes.

1. *H. subaxillaris* (Lam.) Britt. & Rusby, Trans. N.Y. Acad. Sci. 7:10. 1887. CAMPHOR WEED.
   Lat. *sub*, somewhat, *axilla*, axillary — *H. Lamarkii* Cass.

Aromatic plants with a taproot and many branches radiating out from the base of the plant; basal and lower leaves usually petioled, the upper leaves sessile and cordate-clasping; leaves alternate, serrate, pubescent with glandular sticky hairs, acute or short acuminate, elliptic to lanceolate or occasionally oblong, 1-7 cm. long.

Heads numerous, borne all along the branches or in terminal corymbs, showy, radiate, up to 2.5 cm. in di., the rays bright yellow, involucre swollen at the base; bracts imbricated in several series, reflexed after anthesis, linear to lanceolate, green with a scarious white margin, pubescent with sticky glandular hairs; pappus capillary, double, with a short outer series of very small bristles and an inner series of long bristles; achenes of two types, the ray achenes which are thick and glabrous, and the disk achenes which are flat and pubescent.

A more or less weedy plant of the pinelands, roadsides, fields, and cultivated places, with a definite camphor-like odor, sticky leaves and involucre, and attractive bright yellow heads. E.U.S. west to Texas and Arizona, north to Kansas, Ill. and New Jersey. Mexico. [Plate VIII, Fig. A.]

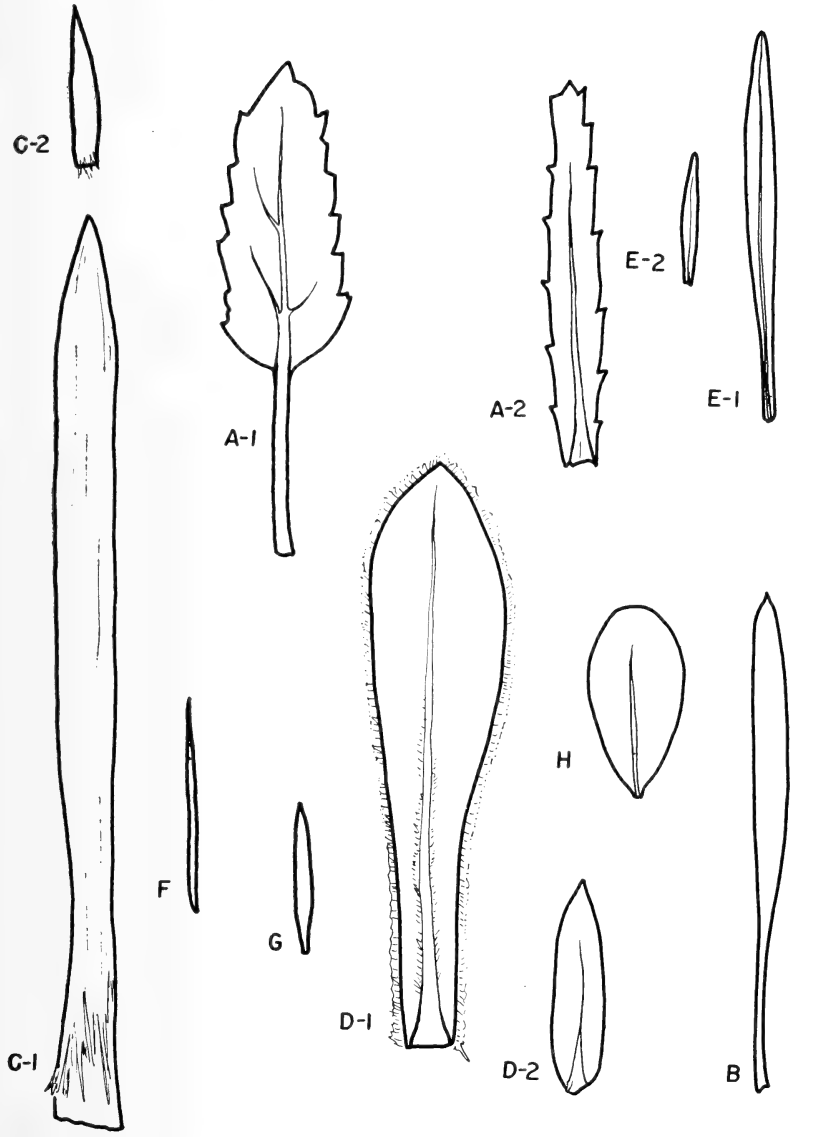

Plate VIII. A. *Heterotheca subaxillaris;* 1. basal leaf, 2. stem leaf. B. *Chondrophora nudata.* C. *Chrysopsis graminifolia;* 1. basal leaf, 2. stem leaf. D. *Chrysopsis floridana;* 1. basal leaf, 2. stem leaf. E. *Chrysopsis hyssopifolia;* 1. basal leaf, 2. stem leaf. F. *Euthamia minor.* G. *Boltonia diffusa.* H. *Seriocarpus bifoliatus.*

16. Chondrophora Raf.

Gk. *chondros,* cartilage, *phorus,* bearing.

1. *C. nudata* (Michx.) Britton, Mem. Torr. Club 5: 317. 1894. RAYLESS GOLDENROD.

Lat. *nudus,* bare. *Biegelowia nudata* (Michx.) DC.

Slender plants with simple stems branched above; stems grooved or angled, glabrous; basal leaves up to 10-12 cm. long, narrowly spatulate, forming a small rosette; stem leaves alternate, few, distant, entire, sessile, thick, small, linear, 3-4 cm. long, becoming scale-like in the inflorescence.

Heads in flat-topped corymbs, discoid, 5-7 mm. high, very narrow, only 3-4 flowered; involucre cylindric, imbricated in several series, the bracts yellow with green tips, appressed, rigid, linear; flowers small, yellow; pappus capillary.

Inconspicuous plants growing only 1 to 2 feet tall and more or less obscured by the surrounding vegetation. The basal leaves form a small rosette, but the stem with its few small leaves set far apart appears to be almost naked; the heads are small and not showy. In low places with acid soil on the west coast above Naples and in Broward County. S.E.U.S. west to Texas and north to Va. [Plate VIII, Fig. B.]

17. Chrysopsis Nutt.

Gk. *chrysos,* gold, *opsis,* aspect, referring to the golden color of the flowers.

Herbs with white silky or glandular pubescence or glabrous; leaves alternate, entire, the basal leaves often quite long and narrow; heads radiate, borne in corymbs, conspicuous with golden ray flowers; involucre imbricated in several series; pappus capillary.

Five species of Chrysopsis have been collected in our area, three of which are very much alike, differing only in the length of the ligules and the height of the involucre. These three species all have narrow leaves that are white silky pubescent or sometimes sparingly so. Individual plants vary a great deal especially in the length of the leaves and the amount of pubescence. *C. graminifolia* is by far the most common of the three.

1. Plants with white silky pubescence throughout, or at least silvery in color.
   2. Ligules less than 1 cm. long.

3. Ligules 7-9 mm. long; involucre 10-12 mm. high ... 1. *C. graminifolia*
3. Ligules 3-4 mm. long; involucre 4-7 mm. high ... 2. *C. microcephala*
2. Ligules over 1 cm. long; involucre 10-12 mm. high ... 3. *C. Tracyi*
1. Plants without white silky pubescence throughout, never silvery in color.
2. Upper part of plant glandular, lower part of plant white cottony ... 4. *C. floridana*
2. Plants completely glabrous or essentially so ... 5. *C. hyssopifolia*

1. *C. graminifolia* (Michx.) Ell. Bot. So. Car. & Ga. 2:333. 1824. GOLDEN ASTER.

Lat. *graminis,* grass, *folium,* leaf.

Plants with stem, leaves, and bracts white silky tomentose; leaves alternate, lanceolate-linear, sometimes the lower leaves are quite broad, up to 1 cm. wide and often quite long, sessile and clasping; stem leaves mostly reduced in size, gradually becoming smaller toward the inflorescence, erect, appressed and overlapping. Inflorescence branches usually many, forming a wide corymb; involucres 10-12 mm. high; ligules 7-9 mm. long.

A conspicuous dry pineland plant growing only 1-2 feet high, the leaves are a grayish-white in color and the heads a brilliant yellow. E.U.S. west to La. and north to New Jersey and Delaware. Bahamas. [Plate VIII, Fig. C.]

2. *C. microcephala* Small, Fl. S.E.U.S. 1182. 1903. GOLDEN ASTER.

Gk. *mikros,* small, *kephale,* head.

Resembling *C. graminifolia* but differing in that the heads are smaller — only 4-7 mm. high and the ligules are only 3-4 mm. long. Not as common. Pinelands. S.E.U.S. west to Texas and north to S. Carolina.

3. *C. Tracyi* Small, Fl. S.E.U.S. 1182. 1903. GOLDEN ASTER.

Resembling *C. graminifolia* but differing in that the leaves are mostly all linear, and the heads are larger — the involucre 10-12 mm. high and the ligules 12 mm. long, the heads about 3-4 cm. in di. Pinelands of southern Florida and the Keys.

4. *C. floridana* Small, Fl. S.E.U.S. 1183. 1903. GOLDEN ASTER.

Young plants forming a rosette, the leaves with soft, white, cottony pubescence; as the plants grow, the new leaves become

glandular hairy but the lower leaves remain white cottony or these leaves disappear so that all the remaining leaves are glandular hairy; lower leaves spatulate, 4-6 cm. long; upper leaves oblong, obtuse, sessile, entire, partially clasping, often recurved on the stem, 2-4 cm. long. Involucre 6-8 mm. high, bracts glandular, acute.

In acid sandy soil of the scrub lands north of Ft. Lauderdale and north of Naples on the west coast. Limited to Pen. Fla. [Plate VIII, Fig. D.]

5. *C. hyssopifolia* Nutt., in Journ. Acad. Phila. 7: 67. 1834.
Hyssopus officinalis L., a mint, the leaves of which are similar to the leaves of this *Chrysopsis*.

Tall, herbaceous plants, woody at the base; stems glabrous; stem leaves numerous, alternate, sessile, linear to linear-spatulate, entire, thickish, one-veined, channeled or grooved, punctate, glabrous or rarely with white cottony pubescence on the lower leaves, largest at the base and gradually becoming smaller, up to 10 cm. long at base of plant but 4-6 cm. long above, average width 2-3 mm; lower leaves forming an elongated rosette. The first leaves which are small and produced in a basal rosette flat on the ground are white cottony and spatulate in shape and narrowed to a short petiole; but these leaves soon disappear as the stem elongates, they dry up and the later leaves are entirely glabrous. Heads 3 cm. in di.; inner bracts 8 mm. long, acute; rays a golden yellow, 10-12 mm. long.

Collected in an acid sandy pocket on Coral Way in Miami. Not common. May be more or less a transient. S.E.U.S. to Ala. [Plate VIII, Fig. E.]

18. Solidago L.

Gk. *solidare*, to strengthen, referring to the supposed healing qualities of some of the species.

Erect herbs often with horizontal rootstalks and woody stems; leaves alternate, basal leaves sometimes the largest and forming a rosette, the stem leaves often suddenly reduced in size, or the leaves gradually reduced in size from the base of the plant upward; stems often simple but more frequently branched above. Heads very numerous, short-stalked, produced in spikes or racemes but

mostly in open panicles, the branches often widely spreading and recurved, the heads frequently unilateral; heads under 1 cm. in di., mostly few-flowered, the ray and disk flowers conspicuously yellow; involucre imbricated in several series; pappus capillary.

There are seven species of goldenrods in south Florida and they present little difficulty in identifying (see Buswell, 1942).

1. Leaves serrate.
   2. Leaves pubescent, partially clasping ..... 1. *S. fistulosa*
   2. Leaves glabrous (or if pubescent only on midrib).
      3. Leaves 3-veined; leaves not twisted nor reflexed ..... 2. *S. Leavenworthii*
      3. Leaves not 3-veined; leaves twisted or reflexed ..... 3. *S. tortifolia*
1. Leaves entire.
   2. All leaves sessile, clasping, twisted at the base; basal leaves not forming a rosette ..... 4. *S. Chapmanii*
   2. Lower leaves petioled, upper leaves sessile, none of them twisted; lower leaves forming a rosette.
      3. Lower leaves linear to lanceolate, thick and fleshy, 2-5 dm. long; upper leaves lanceolate, 5-15 cm. long, more than 2 cm. wide; inflorescence a compact panicle or several panicles ..... 5. *S. sempervirens*
      3. Lower leaves from 5-30 cm. long, usually not thick nor fleshy; upper leaves much reduced, almost scale-like, less than 2 cm. wide; inflorescence a slender spike or raceme.
         4. Lower leaves linear to linear-lanceolate, up to 2½ cm. wide; heads in a slender spike-like raceme, heads not one sided ..... 6. *S. stricta*
         4. Lower leaves narrow, grass-like, less than 5 mm. wide; heads in a narrow one-sided raceme ..... 7. *S. angustifolia*

1. *S. fistulosa* Mill., Gard. Dict. ed. 8: No. 19. 1768. GOLDENROD.
Lat. *fistula*, a hollow reed or stalk.

Plants with horizontal stolons but basal rosettes absent; stems simple, pubescent; leaves numerous, dense, overlapping, serrate or rarely entire, sessile with a clasping base, midrib prominent, widest at the base, pubescent at least on the midrib below, often scabrous, oblong or lanceolate or elliptic, lower leaves sometimes 12 cm. long, upper leaves 2-4 cm. long, the leaves gradually reduced in size upward. Heads secund, in an open panicle, the branches recurved.

This species is easily recognized by the serrate, pubescent often

scabrous, overlapping leaves. In moist acid soil of low pinelands, roadsides, marshes, everglades, etc. Not too common. E.U.S. north to New Jersey and west to La. [Plate IX, Fig. A.]

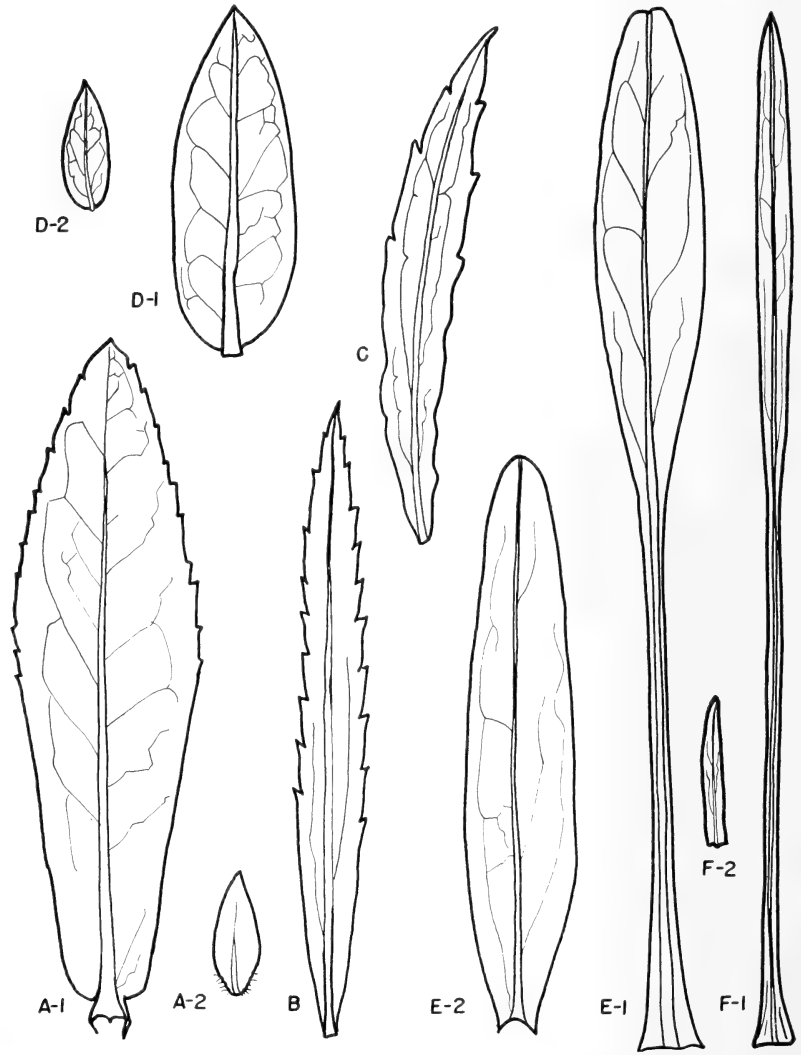

Plate IX. A. *Solidago fistulosa;* 1. basal leaf, 2. stem leaf. B. *Solidago Leavenworthii.* C. *Solidago tortifolia.* D. *Solidago Chapmanii;* 1. lower leaf, 2. upper leaf. E. *Solidago sempervirens;* 1. basal leaf, 2. stem leaf. F. *Solidago angustifolia;* 1. basal leaf, 2. stem leaf.

2. *S. Leavenworthii* T. & G., Fl. No. Am. 2:223. 1841. GOLDENROD.
Named for Dr. M. C. Leavenworth, a southern botanist of the last century.

Plants with long horizontal rootstalks, basal rosettes not conspicuous or absent; stems glabrous or pubescent, grooved; leaves numerous, sessile, not clasping, lanceolate, acute, 3-veined, sharply serrate, glabrous or sometimes with hairs on the midrib, often minutely ciliated on the margins, at least some leaves over 6 cm. long. Inflorescence branches pubescent; heads in long open panicles, the branches widely spreading, heads unilateral.

Easily recognized by the sessile, glabrous, serrate, 3-veined leaves. In damp soil and low places but sometimes in open fields, roadsides, etc. S.E.U.S. north to So. Car.

Caoutchouc occurs in the form of granules in this species. Buswell (1942) states that this species was found most valuable in Edison's experiments as it produced the highest percent of rubber. However, not enough is present to make it a valuable source of rubber. [Plate IX, Fig. B.]

3. *S. tortifolia* Ell., Bot. So. Car. & Ga. 2:377. 1824. GOLDENROD.
Lat. *tortus,* a twisting, *folium,* leaf.

Plants with horizontal stolons but basal rosettes absent; stems pubescent; leaves numerous, overlapping, sessile, serrate with a few short teeth on the upper part of the leaf, mostly less than 6 cm. long but sometimes the lower leaves may be up to 10 cm. long, narrow, less than 8 mm. wide, linear or linear-oblong, glabrous or slightly pubescent on the midrib and margins, the midrib prominent; leaves conspicuously twisted at the base and often drooping on the lower part of the plant. Heads secund on widely spreading branches, the flowers a paler yellow than the other species of goldenrods.

Distinguished from the other species of goldenrods by the narrow, twisted and drooping, glabrous, and sparingly serrate leaves. In dry acid soil of open pinelands. Not common. S.E.U.S. west to Texas and north to Virginia. [Plate IX, Fig. C.]

4. *S. Chapmanii* T. & G., in Proc. Am. Acad. 16, 1881. GOLDENROD.
Named for A. W. Chapman, 1809-1899, an early southern botanist who lived in Florida.

Plants without stolons or rosettes; stems pubescent or sometimes glabrous, often purple in color; leaves dark green, entire, mostly distant, glabrous, punctate, oblong or ovate, sessile or very short-petioled, clasping, base cordate, midvein prominent and often purple in color, apiculate, often revolute, twisted at the base and drooping; leaves up to 6 cm. long and 2 cm. wide. Heads unilateral in spreading panicles, flowers fragrant.

Young plants often seen in the pinelands with very long wand-like stems branched above and with small leaves 1-2 cm. long and 4-6 mm. wide or less. This species is not to be confused with S. *tortifolia;* both have twisted leaves, but in the latter species the leaves have serrate margins. S. *Chapmanii* is a common goldenrod found in both acid and alkaline soil of pineland and scrub land. Florida and Georgia. [Plate IX, Fig. D.]

5. S. *sempervirens* L., Sp. Pl. 878. 1753. GOLDENROD.
Lat. *semper,* forever, *virens,* green. S. *Mexicana* L.

Plants without horizontal stolons but with basal rosettes; stems glabrous or minutely pubescent, sometimes branched below; leaves thick and fleshy, entire, mostly only midvein evident; lower leaves often very long and large, up to 5 dm. long, 4-6 cm. wide, long petioled, linear to lanceolate or elliptic; upper leaves lanceolate to oblong lanceolate, obtuse, sessile and clasping, less than 15 cm. long; leaves gradually reduced in size toward the inflorescence. Heads unilateral, in elongated compact panicle or several panicles, the branches short or little spreading.

Plants usually clustered and growing close together, often forming almost a solid growth in large fields. The large, thick, light colored leaves and dense inflorescence are quite characteristic of this species. Found in salt flats and marshes near the coast, but often found further inland in meadows, glades, and marshes or along roadsides in wet ditches. Fernald (1950) refers the southern plants to *var. mexicana,* ranging from Florida west to Texas and Mexico, north to New York. California, Bermuda, Cuba, Dominican Republic.

6. S. *stricta* Ait., Hort. Kew. 3: 216. 1768. GOLDENROD.
Lat. *strictus,* drawn tight, close. S. *petiolata* Mill.

Slender plants with simple stems, horizontal rootstalks and basal rosettes; stems grooved, pubescent or glabrous; basal and lower

leaves linear-lanceolate or spatulate, entire, glabrous, narrowed to a long petiole, up to 15 cm. long (rarely longer), 2½ cm. wide; stem leaves abruptly and suddenly reduced in size, almost to scales,

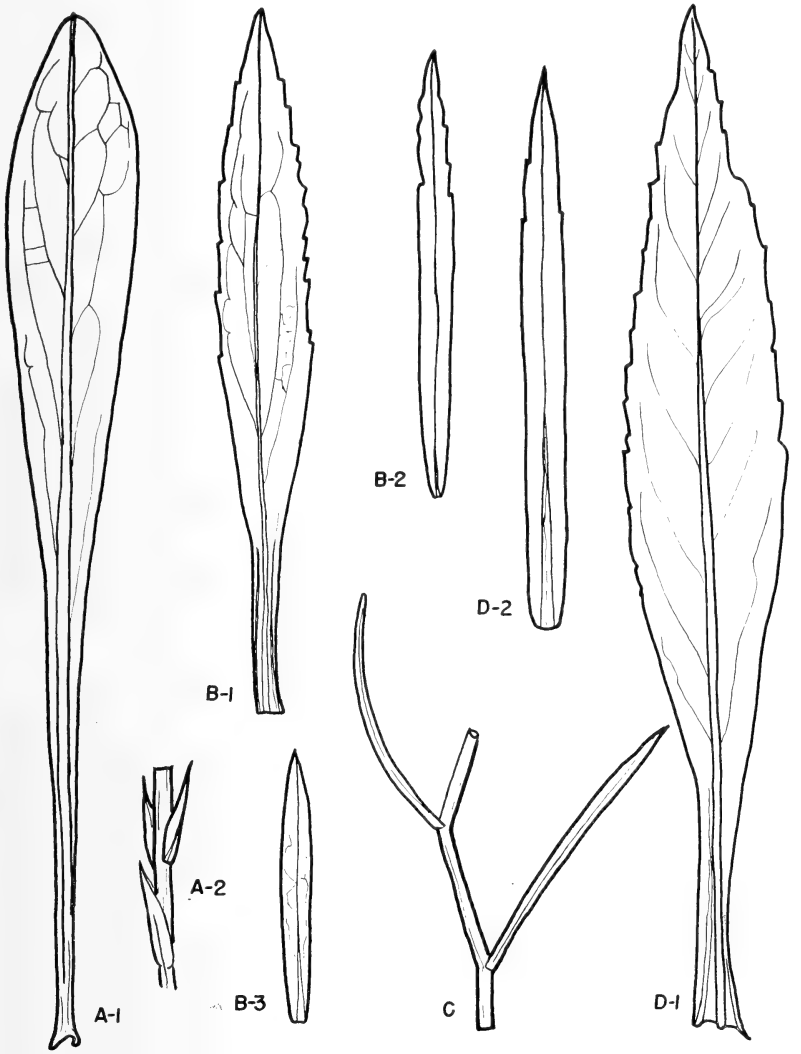

Plate X. A. *Solidago stricta;* 1. basal leaf, 2. stem leaves. B. *Aster Simmondsii;* 1. basal leaf, 2. stem leaf, 3. leaf in the inflorescence. C. *Aster Bracei.* D. *Aster inconspicuus;* 1. basal leaf, 2. stem leaf.

numerous or few, sessile, appressed or spreading, entire, glabrous, up to 3-4 cm. long and 8 mm. wide, elliptic or linear.

Inflorescence spike-like or narrowly paniculate, sometimes only one main axis present and no branches, or the lower branches present and slightly spreading; heads not borne unilaterally.

A common goldenrod of this area recognized by the large leaves forming a rosette and scale-like stem leaves. In rocky and sandy pinelands and also in wet prairies. E.U.S. north to New Jersey and west to Texas. Cuba. [Plate X, Fig. A.]

7. *S. angustifolia* Ell., Bot. So. Car. & Ga. 2: 388. 1824. GOLDENROD.
Lat. *angustis,* narrow, *folium* leaf. *S. petiolata* Mill.

Slender plants with mostly simple stems, horizontal rootstalks, and basal rosettes; leaves entire, glabrous, only midvein evident; lower leaves narrowly linear to linear-spatulate, up to 3-4 dm. long, but less than 5 mm. wide, clustered and grass-like, narrowed to a long petiole; stem leaves distant, sessile, slightly clasping, greatly reduced in size, almost scale-like, less than 6 cm. long and only 1-3 mm. wide. Heads in rather long, narrow, one-sided racemes, the branches very short and little spreading.

This species resembles *S. stricta* but differs in the long, narrow, grass-like lower leaves and the unilateral heads produced in racemes. Not as common as *S. stricta.* Pinelands of Dade County. Cuba. [Plate IX, Fig. F.]

19. EUTHAMIA Nutt.

Gk. referring to the clustered heads.

1. *E. minor* (Michx.) Green, Pittonia 5: 78. 1901
Lat. *minor,* small. *Solidago microcephala* (Greene) Bush.
Solidago minor (Michx.) Fernald.

Stem finely pubescent, branched above the base, branches and main stem somewhat woody; lower part of the plant usually leafless; leaves very numerous, crowded, small, filiform or linear, up to 2½ or 3 cm. long and only 1 or 2 mm. wide, alternate, glabrous, sessile, punctate.

Inflorescence and all branches about equal in height forming a flat-topped corymb; heads small, numerous, few-flowered, radiate;

involucre bracts imbricated, the outer shorter, more or less loosely arranged; rays yellow, the ligules rather small, about 3 mm. long; pappus capillary.

Rather low growing plants only 1 to 2 feet tall forming dense colonies in open fields in sandy acid soil of low pinelands and open fields in northern Dade County, sandy pinelands of the Redlands area, in Broward County, and above Naples on the west Coast. Flowering in the fall months. E.U.S. west to Texas and north to New Jersey. [Plate VIII, Fig. F.]

20. Boltonia L'Her.

Named for James Bolton, English botanist of the 18th century.

1. *B. diffusa* Ell., Bot. So. Car. & Ga. 2: 400. 1824. DOLL'S DAISY.
Lat. *diffusa,* widely spread, probably referring to the distant leaves.

Stems tall, slender, green, glabrous, simple below, little branched above; leaves alternate, small, mostly 3 mm. long or less, few, far apart, sessile, entire, glabrous, elliptic to linear.

Heads radiate, small, on slender peduncles; involucre bracts in several series, narrow, acuminate; rays white or sometimes purplish, numerous, ligules about 6 mm. long; disk flowers yellow; pappus of two bristles and a series of short scales; achenes prominently winged.

Slender herbs with small, distant leaves; the heads resembling *Aster* or *Erigeron* but separated from these two by the pappus which in *Boltonia* is of 2 bristles and not capillary. Not common; found in the Everglades near Pinecrest growing in the open in a few inches of water. S.E.U.S. north to Georgia, west to Eastern Texas and Oklahoma. Mexico (?) [Plate VIII, Fig. G.]

21. Seriocarpus Nees.

Gk. *serikos,* silky, *karpos,* fruit.

1. *S. bifoliatus* (Walt.) Porter, Mem. Torr. Bot. Club. 5: 322. 1894. WHITE-TOPPED ASTER.
Lat. *bi,* twice, *folium,* leaf.

Perennial plants with semi-woody, white hoary pubescent stems; leaves alternate, sessile, entire, thick, rough with minute hairs,

margin ciliate, spatulate to obovate, 2-3 cm. long, erect or spreading, often twisted.

Heads in loose corymbs at ends of branches, radiate, about 1 cm. in di.; involucre up to 10 mm. high, of many series of imbricated, appressed bracts; bracts white, green-tipped, obtuse, leathery, pubescent; rays white, 4-5 in number; disk flowers white; pappus of white silky capillary hairs.

Plants with aster-like heads but separated from that genus mainly by the white disk flowers. Found mostly in dry, acid pinelands; not too common in Miami, more abundant in the acid soil north of Miami; also in Pinecrest. S.E.U.S. north to Va. and west to La. [Plate VIII, Fig. H.]

22. Aster L.

Gk. *asterus*, star, from the radiate head.

Perennial or sometimes annual herbs, or in one species a woody vine, with alternate, simple leaves; leaves sessile or petioled, glabrous or pubescent, entire or toothed, often cordate at the base and occasionally clasping; basal and lower leaves often clustered, petioled and much larger than the other leaves; stem leaves smaller and mostly sessile; leaves of the branchlets and the inflorescence much reduced, sessile and often bract-like; or the leaves may be large at the base of the plant and gradually reduced in size up to the inflorescence.

Heads in corymbose or paniculate inflorescences, mostly conspicuously radiate, the rays rather numerous but not over 30, white, blue, pink, purple, or violet, pistillate; disk flowers always yellow, perfect; involucre bracts imbricated in several series, mostly over three, the outer shorter; pappus capillary; achenes flat or ribbed.

The asters are found in flower in late summer, fall and early winter months. Although they can be easily identified as asters, they usually present some difficulty when one tries to identify the species. Ten species of asters have been recognized as growing in south Florida. Four are rather common but the remaining six are not met with too frequently, mainly because of their restricted habitat or range. The four common species are *A. adnatus* of the pinelands, *A. dumosus* and *A. exilis* of low pinelands, wet prairies and everglades, and *A. Simmondsii* of dry and low pinelands, glades and wet prairies. The remaining six species are *A. Bracei* of the

everglades, *A. carolinianus* of cypress hammocks and river banks, *A. simulatus* of dry pinelands, *A. inconspicuus* of Key West, *A. patens* of acid, sandy soil in the Pinecrest area, and *A. Elliottii*, the rarest species, found in marshy places.

1. At least some of the leaves sessile with the base definitely clasping the stem.
   2. Plants woody, climbing ..... 1. *A. carolinianus*
   2. Plants not woody nor climbing.
      3. Upper leaves scale-like, appressed, and the lower part of the leaf adnate to the stem ..... 2. *A. adnatus*
      3. Leaves not scale-like nor adnate to the stem.
         4. All leaves sessile.
            5. Some of the leaves with auriculate clasping bases; plants without stoloniferous rootstalks, leaves on the inflorescence branches numerous and reduced to scales or bracts; majority of leaves entire; heads up to 3 cm. in di. ..... 3. *A. patens*
            5. Lower leaves only partially clasping; plants with stoloniferous rootstalks; leaves on the inflorescence branches few, not reduced to mere scales or bracts; majority of leaves serrate; heads less than 3 cm. in di. ..... 9. *A. Simmondsii*
         4. Some of the leaves, especially the lower one, narrowed to a petiole; majority of the leaves definitely serrate; heads crowded at the end of each branch ..... 4. *A. Elliottii*

1. Leaves sessile or petioled but none of them definitely clasping the stem.
   2. Stem wiry; leaves few in number, distant, thick and somewhat fleshy, glabrous, acute, entire, linear-subulate ..... 5. *A. Bracei*
   2. Stem not wiry; leaves numerous, not thick nor fleshy, glabrous or pubescent.
      3. Leaves and bracts of the involucre with a soft silky or canescent pubescence ..... 6. *A. simulatus*
      3. Leaves and bracts pubescent or glabrous, but the pubescence not of a silky type.
         4. All leaves entire or essentially so; plants without stoloniferous rootstalks.
            5. Some of the leaves, mostly the basal ones, petioled; some stem leaves partially clasping the base of the branch; ligules mostly pale purple ..... 7. *A. exilis*
            5. All leaves sessile; none of the leaves clasping; ligules mostly white ..... 8. *A. dumosus*
         4. Some of the leaves definitely serrate.
            5. Margin of the lower leaves ciliate; plants with stoloniferous rootstalks; heads over 1 cm. in di. ..... 9. *A. Simmondsii*
            5. Margin of the lower leaves not ciliate; plants without stoloniferous rootstalks; heads 5-7 mm. in di. ..... 10. *A. inconspicuus*

1. *A. carolinianus* Walt., Fl. Carol. 209. 1788. CLIMBING ASTER.

Woody vine with many branches; stems grayish pubescent, older parts becoming glabrous; basal and lower leaves narrowed below the middle and with a clasping base; upper stem leaves rather few and distant, entire, 1-4 cm. long, acute or short acuminate, clasping, frequently the base clasping nearly around the stem on young shoots, soft pubescent with short hairs; older stems often with thorn-like branches.

Heads all along the upper part of the stems; heads peduncled, the peduncle 3-4 cm. long; involucre up to 1 cm. high, the bracts conspicuously recurved or spreading with green spatulate tips, white hairy; heads up to 3-4 cm. broad, showy; ligules numerous, 1-2 cm. long, pale pink with a touch of lavender or rose-purple.

An attractive vine with large showy heads, sometimes planted in the garden. The many branches climb or arch over trees and shrubs often forming thickets. Found in low moist places along streams, low hammocks, and in cypress swamps. S.E.U.S. north to South Carolina. [Plate XI, Fig. C.]

2. *A. adnatus* Nutt., in Journ. Acad. Phila. 7: 82. 1834. ASTER.
Lat. *adnasci*, joined to, referring to the upper leaves.

Much branched, erect or more or less reclining herbs with partially woody stems; young plants little-branched; stems wire-like and stiff, hispid; leaves alternate, scabrous, sessile, clasping, the lower and basal leaves up to 4-5 cm. long, the upper leaves small and scale-like, appressed to the stem and overlapping, the lower part of the leaf adnate to the stem and decurrent, acute, lanceolate; the leaves becoming progressively smaller and scale-like or bract-like and toward the top of the stem merging into the involucre.

Heads terminating the many scaly branches; involucre up to 1½ cm. high, the bracts green-tipped, slightly spreading; heads 2 cm. in di., ligules lilac or light blue to pale white; pappus white tawny silky.

Typical plants of dry and rocky pinelands. Sometimes the plants are less than 1 foot high; other times the plants grow to form large clumps, the many wiry and scaly branches arching over other

vegetation. S.E.U.S. to Miss. and Ga. Bahamas. [Plate XI, Fig. A.]

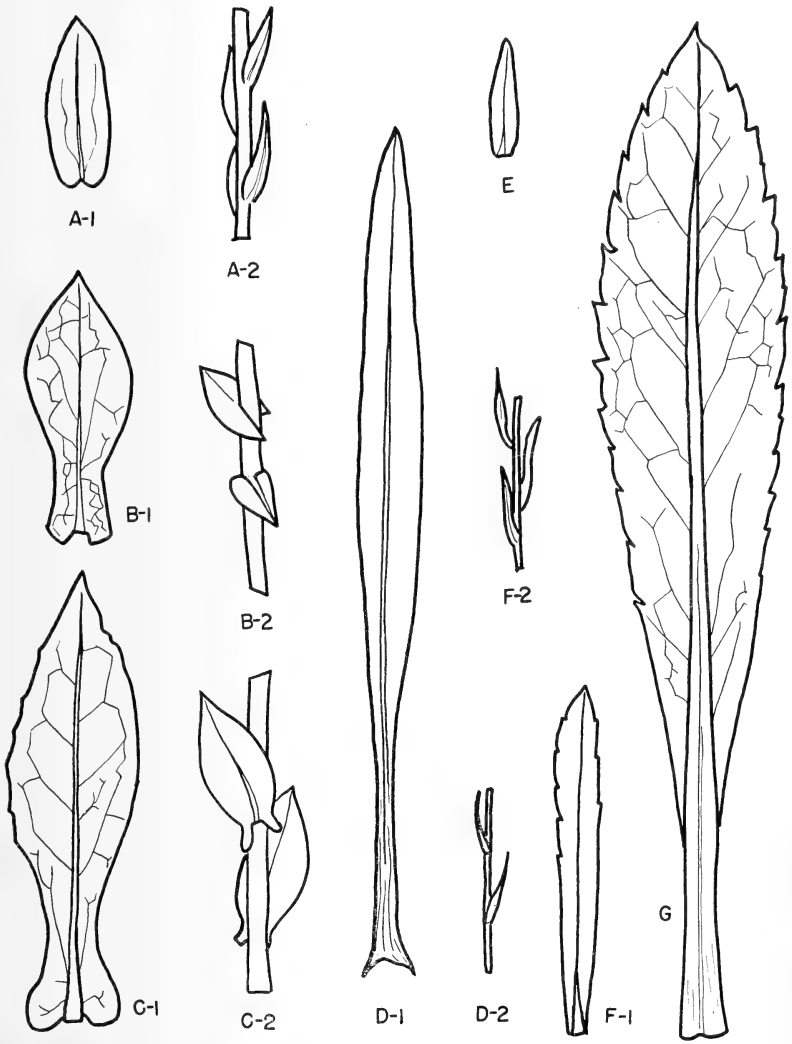

Plate XI. A. *Aster adnatus;* 1. lower leaf, 2. upper stem leaves. B. *Aster patens;* 1. lower leaf, 2. upper stem leaves. C. *Aster carolinianus;* 1. lower leaf, 2. upper stem leaves. D. *Aster exilis;* 1. lower leaf, 2. upper stem leaves. E. *Aster simulatus.* F. *Aster dumosus;* 1. lower leaf, 2. upper stem leaves. G. *Aster Elliottii.*

3. *A. patens* Ait., Hort. Kew 3: 201. 1789. ASTER.
Lat. *patens*, spreading, referring to the spreading habit.

Plants much branched above, the branches widely spreading and forming a low bushy plant; stems pubescent; young leaves soft pubescent, older leaves rough pubescent; leaves sessile, clasping, thick, rigid, acute, lanceolate to oval or elliptic, margin ciliate on lower half of leaf; lower leaves up to 10 cm. long, remotely serrate; upper leaves under 6 cm. long, entire; leaves of the inflorescence branches very numerous, scale-like or bract-like.

Heads solitary at ends of branchlets, borne all along the spreading branches; heads 2-3 cm. in di.; ligules purplish blue or pink or violet; bracts of the involucre spreading, pubescent and ciliate; pappus tawny color.

Confined to dry open places where the soil is acid and sandy. Collected at Pinecrest, Monroe County. E.U.S. west to Texas and north to Minn. and Maine. [Plate XI, Fig. B.]

4. *A. Elliottii.* T. & G., Fl. No. Am. 2: 140. 1841. ASTER.
Named for Stephen Elliott, 1771-1830, a botanist of South Carolina.

Rather tall plants much branched above; stem sparingly pubescent or conspicuously hairy; leaves rather large, numerous, thickish, serrate, acute or apiculate, glabrous, somewhat resembling leaves of *solidago sempervirens;* lower leaves mostly oblanceolate to elliptic, narrowed to a winged petiole, the base clasping; upper leaves lanceolate sessile, little-clasping.

Heads numerous in rather compact panicles, more or less crowded at the end of each branch; heads 2½-3½ cm. in di.; bracts of the involucre narrow, numerous, recurved, the tips spreading; rays with purple to pink ligules.

Attractive plants with large, thick leaves and showy pink to purple heads. Usually forming large colonies in swamps and low places. Collected at Deep Lake, Facahatchee cypress swamp, and along the canal on the road leading to Pinecrest, Monroe County. S.E.U.S. from Florida to La. and So. Va. [Plate XI, Fig. G.]

5. *A. Bracei* Britton, in Small's Fl. Miami, 190. 1913. ASTER.
Named for Lewis J. K. Brace, who collected plants in the Bahamas from 1875-1920.

Slender plants with simple stems, little-branched above; stems wiry and somewhat zig-zag; leaves linear, subulate, few in number, entire, pointed, thick and somewhat fleshy, glabrous, sessile, up to 6 cm. long.

Heads rather small, mostly less than 1 cm. in di.; bracts of the involucre pointed, narrow, lanceolate; ligules white to pinkish lavender or pink.

Stems with long internodes, the lower leaves often dropping off leaving a long partially zig-zag stem with few or no leaves except for a few greatly reduced scale-like leaves subtending each branch in the inflorescence. Found mostly in open places in the everglades and wet prairies. Mostly in southern Florida and some of the Keys, but apparently spreading northward for it has been collected recently by Curtis Jackson in a salt marsh, St. Marks Refuge near Tallahassee, Florida. Also Bahamas, Cuba. [Plate X, Fig. C.]

6. *A. simulatus* Small, in Bull. Torr. Bot. Club. 51: 388. 1924.
ASTER.

Gk. *simulare,* to liken, resembling *A. concolor.*

Plants with simple wand-like stems without branches, the plants often bending over, or occasionally some plants growing in large groups are erect and up to 9 or 10 cm. tall; somewhat woody at base; basal and lower leaves up to 5 or 6 cm. long, sometimes glabrous; stem leaves sessile, 1 or 2 cm. long, or rarely more, scale-like, alternate, entire or minutely serrate, erect and appressed to the stem, elliptic or elliptic-lanceolate to linear, acute or mucronate; leaves with silky or canescent pubescence giving a soft feeling to the touch; leaves becoming progressively smaller from base of the plant to the top.

Heads in an elongated raceme resembling *Liatris* inflorescence; involucre soft white hairy, bracts acute, green-tipped, appressed, linear-elliptic to lanceolate; heads about 1 cm. in di., ligules violet-blue or lilac or sometimes whitish to pinkish; pappus a light tawny color. [Plate XI, Fig. E.]

A. simulatus resembles *A. concolor* but differs mainly in the length and size of the leaves — in *A. concolor* the leaves are 4-5 cm. long while in *A. simulatus* the leaves are only 1-2 cm. long or less, almost scale-like. *A. concolor* has not been collected in this part of

Florida and probably *A. simulatus* represents the southern form. Found only in dry pinelands of Dade County.

7. *A. exilis* Ell., Bot. So. Car. and Ga. 2: 344. 1824. ASTER.
Lat. *exilis,* small, thin, slender.

Usually much branched, more or less weedy plants with divergent branches; stems glabrous, somewhat fleshy, lower part often woody; leaves somewhat fleshy and thick, glabrous, entire or rarely serrate, sessile; lower and basal leaves sessile or narrowed to a winged petiole, lanceolate to oblanceolate; some stem leaves subtending the branches usually long and narrow, elliptic to lanceolate or oblanceolate, sessile and more or less clasping the branch; leaves on the branchlets much reduced, almost scale-like, few and distant.

Heads numerous, panicled, produced on short branches, the branches with a few scale-like leaves; heads less than 1 cm. in di.; ligules pale purple.

Distinguished by the small, numerous pale-purple heads and some of the stem leaves semi-clasping; all leaves entire or rarely serrate, the basal leaves often petioled. Found mostly in moist places along streams, canals, wet banks, everglades, wet prairies, etc. S.E.U.S. north to So. Car. and west to Texas, Arizona, Kan. and Mo. California. Bahamas, Cuba. [Plate XI, Fig. D.]

8. *A. dumosus* L., Sp. Pl. 873. 1753. ASTER.
Lat. *dumosus,* bushy.

Stems glabrous, usually much branched and forming a bushy plant; lower and basal leaves spatulate or lanceolate, mostly entire but sometimes obscurely serrate, sessile; stem leaves sessile, entire, sometimes rough margined, often erect, linear or mostly broader at base and even deltoid-like, 2-7 cm. long, becoming smaller towards the top of the stem; leaves of the inflorescence small and scale-like, erect, little appressed, flexible.

Heads solitary at ends of very small branchlets, stalked, the peduncles often as much as 10 cm. long; bracts subulate, linear, appressed, obtuse, green, resembling leaves on the peduncle, ciliate; heads about 1 cm. in di., rays white or rarely pink or violet.

Distinguished by all the leaves sessile, entire, none semi-clasping; heads small, 10-12 mm. in di., ligules mostly white. In moist places

such as glades, wet prairies, everglades, but sometimes in pinelands. E.U.S. west to Texas, and north to Canada. Cuba, Haiti, Dominican Republic. [Plate XI, Fig. F.]

A. dumosus L. var. *coridifolius* (Michx.) T. & G.

Lat. *corium,* leather, *folius,* leaf. *A. coridifolius* Michx.

Basal leaves as in the species, but all the rest of the leaves of the plant are of the same type — small (1 cm. or less in length), linear, almost bract-like, rather numerous, mostly erect and somewhat appressed to the stem and almost overlapping each other, or spreading, hard and firm. Heads smaller, less than 1 cm. in di.; rays white.

More characteristic of pinelands rather than low places. E.U.S. west to La. and north to New Jersey and Illinois.

9. *A. Simmondsii* Small, Fl. Miami. 190. 1913. ASTER.

Named for Edward Simmonds, plant introducer in early Miami. *A. Sulznerae* Small.

Mostly tall but sometimes low herbs spreading by stoloniferous rootstalks, often much branched above. Mature plants with four types of leaves: (1) lower leaves long, up to 10 or 12 cm., oblanceolate, serrate, partially clasping; (2) main stem leaves which are long and quite prominent and subtend the branches, serrate or entire, partially clasping; (3) leaves of the branches which are much smaller, entire, linear; (4) leaves of the branches which are almost scale-like. All leaves sessile, some with cilia on the lower part of the leaf.

Heads solitary, produced all along the branches on peduncles up to 3 or 4 cm. long; heads mostly over 2 cm. in di., often quite showy; bracts green-tipped, spatulate, appressed, acute, scarious-margined below the green tip; ligules pale violet or pink-purple or rarely white.

Distinguished by the serrate leaves, cilia on the margins of the leaves, heads over 1 cm. in di. and the stoloniferous rootstalks. In moist places along canals, in glades and wet prairies, etc., but also in dry pinelands of the Miami area. Common and showy. Confined to southern Florida but reported from the Gainesville area (Murrill, 1945). *Aster Simmondsii* and *A. dumosus* have been used by the Seminole Indians in an infusion for sunstroke. [Plate X, Fig. B.]

10. *A. inconspicuus* Less., in Linnaea 5: 143. 1830. ASTER.

Tall, annual, much branched herbs, glabrous throughout; stems somewhat zig-zag above; leaves somewhat thick and fleshy, elliptic, up to 15-20 cm. long and 2.5 to 3 cm. wide, sessile or with a short winged petiole, somewhat clasping, acute, serrate but the teeth few and not too close together and mostly above the middle of the leaf, leaves of the branches smaller and more of a linear type.

Heads in widely spreading panicles; involucre 4-5 mm. high, bracts linear with dark-colored, acute to acuminate tips; heads only 5-7 mm. in di.; rays 20 to 30 in number, ligules light violet to whitish; disk flowers 10 to 12 in number, less than the ray flowers.

Distinguished by the fleshy, serrate leaves and the small heads with the ray flowers more numerous than the disk flowers. Originally found only in Key West along roadsides, but spreading northward to the Cutler area; recently established on the University of Miami campus as a weed. Cuba, Dominican Republic, Antilles. [Plate X, Fig. D.]

23. ERIGERON L.

Gk. *eri,* very, *geron,* an old man, referring to the early hoarness of some of the species.

Herbs with alternate, sessile or petioled, entire or toothed leaves, the leaves often basal forming a rosette; heads radiate, resembling *Aster,* many-flowered, the rays often very numerous — as many as 100; bracts narrow, equal, in one or two or rarely three series; heads produced on mostly naked peduncles; disk flowers yellow, numerous; rays white, pink, or violet; pappus capillary; achene flattened.

1. Perennial plants with basal rosettes and a central scape.
   2. Ray flowers over 100 in number; basal leaves mostly lobed, oblanceolate to obovate, pubescent ..... 1. *E. quercifolius*
   2. Ray flowers less than 50 in number; basal leaves never lobed, entire or toothed, spatulate, glabrous ..... 2. *E. vernus*
1. Annual plants, the stems leafy, much branched ..... 3. *E. ramosus*

1. *E. quercifolius* Lam., Table, Encyc. 3, 258. 1823. SOUTHERN FLEABANE.

Lat. *quercus,* oak, *folium,* leaf.

Main leaves basal forming a rosette; leaves alternate, pubescent, sometimes very densely so, soft to the touch, lobed and with short

blunt apiculate tips to the lobes; sometimes leaves entire with a wavy margin or occasionally serrate; leaves 5-12 cm. long, sessile or very short-petioled, petiole sometimes winged, oblanceolate to ovate or spatulate; stem leaves sessile, clasping, spatulate to linear or lanceolate, small and distant, only 2 to 4 present, toothed or entire, pubescent.

Heads borne in a corymb at end of the scape which arises from the center of the rosette; heads showy with 100 or more white or sometimes purplish or pinkish ligules, ligules 4-5 mm. long; bracts pubescent.

Easily identified by the oak leaf-shaped basal leaves forming a rosette flat on the ground. Sometimes plants will be found with the leaves rather small, only 2-3 cm. long, and entire, not lobed at all. In lawns, grassy places, roadsides, sink holes, pinelands, cultivated places, etc., where the soil is not too dry. Common. S.E.U.S. west to Texas and north to south Virginia and Tenn. Bahamas, Cuba, Haiti, Dominican Republic. [Plate XII, Fig. A.]

2. *E. vernus* (L.) T. & G., Fl. No. Am. 2, 176. 1841. DAISY FLEABANE.

Lat. *vernus,* of spring.

Main leaves basal forming a rosette, scape from the center of the rosette, little-branched above into a corymb, the heads solitary on the branches; basal leaves thickish, glabrous, entire or with a few teeth, spatulate, up to 7-8 cm. long but usually less, petiole winged; stem leaves few, distant, scale-like. Heads few with less than 50 white or rarely pink ligules.

Low growing plants found in low, moist, mostly acid pinelands. Not too common in our area. S.E.U.S. west to La. and north to Virginia. [Plate XII, Fig. B.]

3. *E. ramosus* (Walt.) B.S.P., Prelim Cat. N. Y. 28. 1888. FLEABANE DAISY.

E. strigosus Muhl. Lat. *ramus,* a branch.

Mostly rather tall, weedy plants, much branched above, rough pubescent; basal and lower leaves oblong or spatulate, petioled, toothed; stem leaves entire, lanceolate or linear, sessile, distant, rather long. Bracts pubescent; rays white.

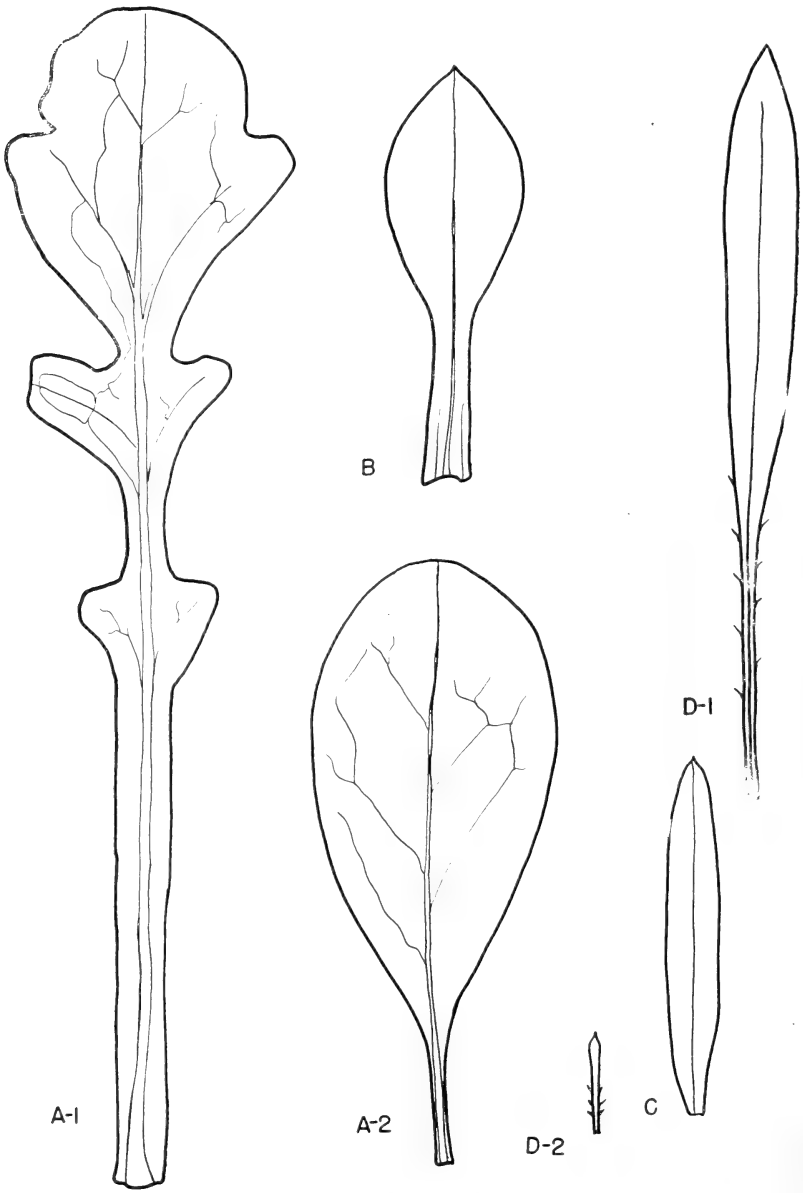

Plate XII. A-1 and A-2. *Erigeron quercifolius.* B. *Erigeron vernus.* C. *Erigeron ramosus.* D. *Leptilon pusillum;* 1. basal leaf, 2. stem leaf.

This is probably one of the transient species occasionally found in this area but never becoming firmly established. Collected by Dr. W. M. Buswell in Royal Palm Hammock several years ago. Growing mostly along roadsides and in cultivated places. Found throughout most of North America. [Plate XII, Fig. C.]

24. Leptilon Raf.

Gk. *leptos,* slender, small, referring to the small heads.

1. Plants essentially glabrous except for the cilia on the margins of the leaves; bracts of the involucre purple-tipped ..... 1. *L. pusillum*
1. Plants pubescent; bracts of the involucre green throughout ..... 2. *L. canadense*

1. *L. pusillum* (Nutt.) Britton, Torreya 14; 198. 1914. horse weed.
Lat. *pusillus,* very small, referring to the small heads. *Erigeron pusillum* Nutt.

Tall, weedy plants, usually much branched above; stems grooved, glabrous or essentially so; leaves alternate, lanceolate to linear, narrow, long, becoming smaller toward the top of the plant, entire or with a few small teeth on the upper part of the lower leaves, ciliated on the margins especially on the lower part of the blade, leaves often twisted or curled.

Stem paniculate above producing the heads all along the branches; heads small, whitish, mostly less than 6 mm. in di.; involucre campanulate, bracts in three series or less, the inner longer, with conspicuously red tips; heads inconspicuously radiate, the rays erect or mostly spreading and flat, white; pappus capillary.

A common weed of cultivated places, roadsides, fields, waste places, etc. E.U.S. west to Texas and Tenn. and north to Mass. Throughout the West Indies, Mexico, Central America and South America. [Plate XII, Fig. D.]

2. *L. canadense* (L.) Britton, Torreya 14, 198. 1914. horse weed.
Erigeron canadensis L.

Resembling *L. pusillum* but differing in not having the red-tipped bracts and the plants are pubescent. This species does not seem to be nearly as common as the preceding species. Ranges throughout the most of United States and Canada. In Hawaii this plant is a source of an insect repellent oil.

25. Baccharis L.

Gk. *Bacchus,* god of wine, originally applied to some other shrub.

Tall, much branched, dioecious shrubs with alternate, resinous-dotted, aromatic, glabrous, entire or toothed leaves which are often decurrent on the stem; heads discoid, many flowered; involucre bracts imbricated in several series, bracts smaller in the staminate heads; flowers greenish-white to yellowish; pistillate flowers with a filiform corolla, staminate flowers with a larger tubular corolla which is five-lobed; pappus of conspicuous capillary bristles, shorter in the staminate flowers; achenes small, ribbed, terete, glabrous.

When the pistillate flowers are mature they are very conspicuous with the silvery pappus giving the plants a silvery appearance from a distance; hence the name of silver bush.

1. Leaves linear; heads sessile ..... 1. *B. angustifolia*
1. Leaves obovate; heads sessile or peduncled.
   2. Leaves toothed.
      3. Heads peduncled, produced at ends of branches; leaves a dark green color, coarsely toothed ..... 2. *B. halimifolia*
      3. Heads sessile, produced in axils of the leaves; leaves a light green in color, sparingly toothed ..... 3. *B. glomeruliflora*
   2. Leaves entire ..... 4. *B. dioica*

1. *B. angustifolia* Michx., Fl. Bor. Am. 2: 125. 1803. FALSE WILLOW.

Lat. *angustus,* narrow, *folia,* leaf.

Leaves linear, entire or with a few minute teeth, up to 5-6 cm. long, less than 8 mm. wide. Heads sessile, solitary or 2-4 grouped together near the ends of the branches but in the axils of the leaves; involucre 4 mm. high, the bracts brown when flowers mature.

Roadsides, salt marshes, shores, edges of mangrove swamps, and sometimes pinelands. S.E.U.S. west to Texas and north to North Carolina. Bahamas. [Plate XIII, Fig. I.]

2. *B. halimifolia* L., Sp. Pl. 860. 1753. GROUNDSEL BUSH, SILVER BUSH, SALT BUSH, SEA MYRTLE.

Leaves resembling some species of *Halimium.*

Stems angled by the decurrent leaves; leaves obovate, coarsely toothed above the middle, thick and leathery, dark green, sessile,

decurrent, with dark green resinous glands on both surfaces; leaves near the ends of the branches smaller, entire, oblanceolate. Heads peduncled at the ends of the branches; involucre 5-6 mm. high.

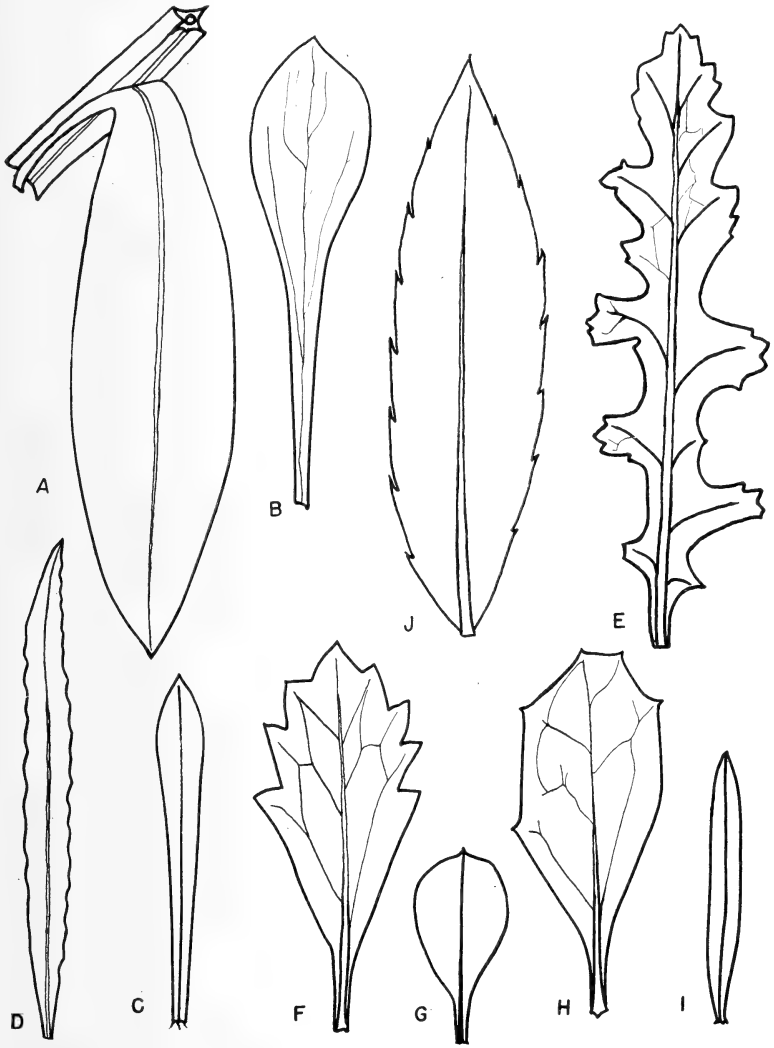

Plate XIII. A. *Pterocaulon undulatum.* B. *Gnaphalum spathulatum.* C. *Gnaphalum falcatum.* D. *Gnaphalum polycephalum.* E. *Berlandiera subacaulis.* F. *Baccharis halimifolia.* G. *Baccharis dioica.* H. *Baccharis glomeruliflora.* I. *Baccharis angustifolia.* J. *Eclipta alba.*

This species of *Baccharis* is more common than the other three species. Found in salt marshes, beaches, edges of mangrove swamps, and sometimes in pinelands, hammocks, and along roadsides. E.U.S. west to Texas and north to Mass. Bahamas, Cuba, Mexico, Central America. [Plate XIII, Fig. F.]

3. *B. glomeruliflora* Pers., Syn. 2: 423. GROUNDSEL BUSH.
Lat. *glomeris,* a ball.

Shrubs resembling *B. halimifolia* but the leaves are smaller and usually with only a few sharp teeth on the upper part of the leaf; leaves a lighter green color and more decurrent on the stems; the heads are sessile in the axils of the leaves and borne close together to form a globular cluster.

Salt marshes, swamps, edges of hammocks, and sometimes roadsides and rarely pinelands. S.E.U.S. north to North Carolina. Bermuda, Cuba, Bahamas (?). [Plate XIII, Fig. A.]

4. *B. dioica* Vahl., Symb. Bot. 3: 98. 1794. GROUNDSEL BUSH.
Gk. *di,* two, *oikos,* house.

Shrubs resembling *B. halimifolia* but the leaves are entire, 1-3 cm. long, clustered at the ends of the branches, obovate or spatulate, apiculate. Not common in our area. Confined to certain hammocks especially near the coast on Cutler Road below Miami. Bahamas, Cuba, Haiti, Dominican Republic, Puerto Rico, St. Croix, Jamaica. [Plate XIII, Fig. G.]

26. PLUCHEA Cass.

Named for Abbe N. A. Pluche, French naturalist of the last century.

Herbs or shrubs with alternate, pubescent, aromatic, toothed, and prominently veined leaves; heads in corymbs and clustered, discoid, many-flowered; involucre imbricated; pistillate flowers marginal and with a filiform corolla; central flowers perfect, the corolla five-parted and with a swollen throat and 5-lobed; flowers purple or rose-purple; pappus capillary.

The Plucheas are easily recognized by the small reddish purple heads, the pubescent leaves, and camphor-like odor.

1. Leaves sessile, cordate clasping ..... 1. *P. foetida*
1. Leaves petioled or nearly sessile, but not clasping.
   2. Herbs.
      3. Majority of the leaves ovate ..... 2. *P. purpurascens*
      3. Majority of the leaves elliptic ..... 3. *P. petiolata*
   2. Shrubs ..... 4. *P. odorata*

1. *P. foetida* (L.) B.S.P., Prelim. Cat. N. Y. 28: 1888. MARSH FLEABANE.

Lat. *foetidus,* ill-smelling.

Herbaceous, tomentose, aromatic plants; leaves thick, sessile, cordate clasping, twisted, distant, serrate with gland-tipped teeth; young leaves very soft tomentose, entire, elliptic; mature leaves ovate to broad elliptic or oblong.

Heads at ends of branches, clustered, in corymbs; bracts acute, pubescent, recurved or spreading, red-tipped; flowers many, purple.

In low places in glades, wet prairies, everglades, low pinelands, etc., in both acid and alkaline soil. Differing from the other species by the sessile, clasping leaves. E.U.S. west to Texas and Mo. and north to New Jersey. Bahamas, Cuba. Mexico, Yucatan. [Plate XIV, Fig. B.]

2. *P. purpurascens* (Sw.) DC., Prod. 5: 452. 1836. MARSH FLEABANE.

Lat. *purpurascens,* becoming purple.

Herbaceous plants; stems somewhat woody, soft white pubescent, solitary or little-branched at base; leaves short petioled or nearly sessile, mostly ovate, the upper leaves ovate-lanceolate to elliptic, up to 10 cm. long, dentate-serrate, mostly densely soft pubescent.

Inflorescence a corymb with many branches; involucre 4-5 mm. high; inner bracts rose-purple, lanceolate, short acuminate, outer bracts shorter, green, ovate.

Mostly in drier places than the next species — in pinelands, roadsides, sandy places, but often in glades and edges of salt flats. Often plants are found in dry pinelands that have thick almost succulent leaves that are small, only 3-6 cm. long. This species has the majority of leaves ovate in outline. S.E.U.S. west to Texas and north to Virginia. California. Throughout the West Indies, Central America and South America. [Plate XIV, Fig. C.]

3. *P. petiolata* Cass., in Dict. Sci. Nat. 52: 2. 1826. MARSH FLEABANE.

Lat. *petiolus,* stalk. *P. camphorata* (L.) DC.

Plants greatly resembling *P. purpurascens,* but differing in the following respects; the leaves are almost always elliptic and some-

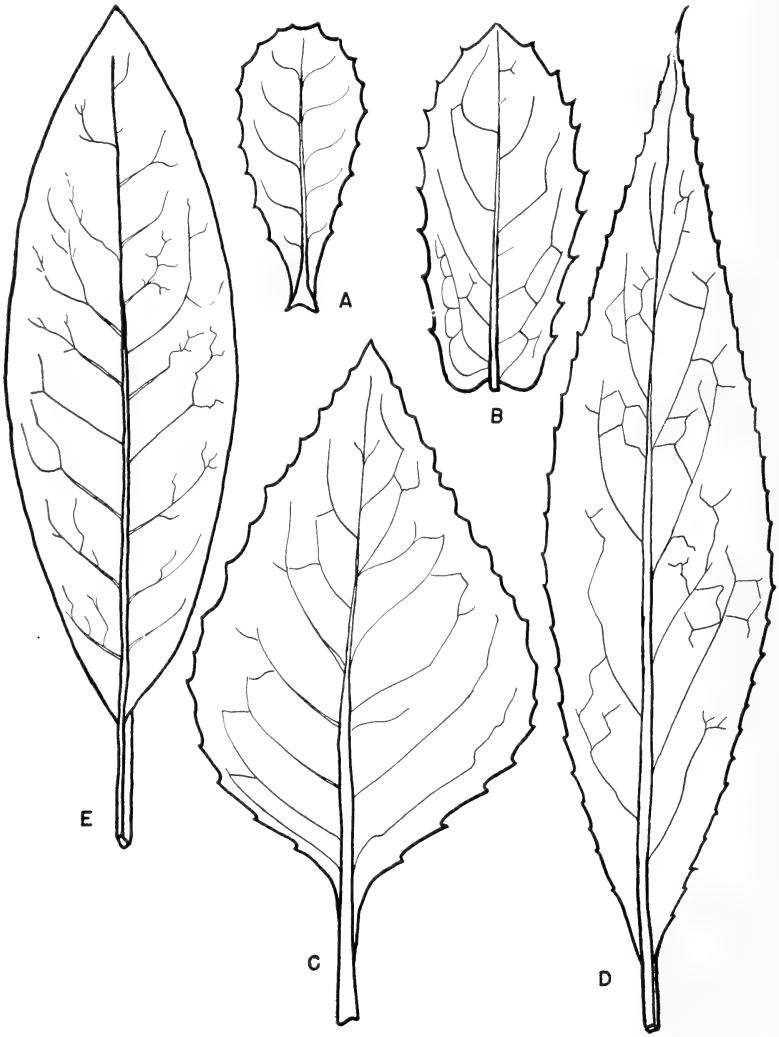

Plate XIV. A. *Sachsia bahamensis.* B. *Pluchea foetida.* C. *Pluchea purpurascens.* D. *Pluchea petiolata.* E. *Pluchea odorata.*

times very long, up to 25 cm., but usually in well developed plants the leaves are 10-15 cm. long; leaves not as hairy, in fact some of the leaves may be quite glabrous except on the midrib below; the stem also may be more or less glabrous; bracts of the involucre are thinner, the inner ones short acuminate with only a few scattered hairs so a hand lens is really necessary to make out the pubescence.

Prefers wetter places — glades, marshes, ditches, salt flats, wet prairies, etc. E.U.S. west to Texas and Mo. and north to Del. [Plate XIV, Fig. D.]

4. *P. odorata* Cass., in Dict. Sci. Nat. 52: 2. 1826. BUSHY FLEABANE. Lat. *odorata*, sweet smelling.

A shrub up to 2 or 3 meters high, much branching above, stems white hairy; leaves elliptic, 8-15 cm. long, more or less clustered at the ends of branches, petioled, remotely serrate or entire, acute, pubescent on the lower surface, midrib brown hairy; leaves not as aromatic as the other species.

Heads in dense corymbs, the corymbs terminal, fragrant; bracts pubescent, red-tipped.

Found at edges of pinelands and hammocks, along canals and roads, etc., usually preferring more or less low ground. Introduced (or native?) from tropical America and naturalized in southern Florida as far north as the Miami area. Throughout the West Indies, Mexico, Central America and South America. [Plate XIV, Fig. E.]

27. SACHSIA Griseb.

Named for Van Sachs, German physiologist of the 19th Century.

1. *S. bahamensis* Urban., Symb. Ant. 3: 408. 1903.

Small plants forming rosettes up to 10 cm. in di.; leaves alternate, up to 6 or 7 cm. long, oval or spatulate, 2-3 cm. wide, thick, dark green above and dull green below, more or less scabrous, midrib prominent, soft hairy below, tuft of light brown hairs at the base of the leaves, margins toothed; leaves thick and leathery with several pockets or "bubbles" on the lower surface making the leaf appear bulged; only a few scale-like leaves present on the scape.

Scape from the center of the rosette, up to 5 dm. tall but more often smaller, slightly scabrous, sparingly branched above; heads

discoid, not showy; involucre cylindric or sometimes swollen at the base, bracts imbricated in several series, the outer shorter, inner much longer, hairy, acuminate, ciliate; flowers small, not showy, long and narrow, tubular or filiform, the lobes of the corolla not spreading or but little; flowers white or yellowish; pappus capillary.

Rather unusual, rare plants with conspicuous leaves but easily overlooked for the small rosettes grow flat on the ground or on rocks and are more or less covered by the surrounding vegetation; the heads are not showy and also easily overlooked. Found in rocky and dry pinelands south of Miami. Bahamas, Cuba. [Plate XIV, Fig. A.]

28. Pterocaulon Ell.

Gk. *pteron,* wing, *kaulos,* stem.

1. *P. undulatum* (Walt.) C. Mohr., in Contrib. U.S. Nat. Herb. VI. 120, 790. 1901. BLACK ROOT, RABBIT TOBACCO.

Lat. *undulatus,* wavy, referring to the wavy margin of the leaf.

Erect but rather low growing herbs with large, thick, black roots; stems tomentose or woolly, conspicuously winged by the decurrent leaves; leaves alternate, densely white woolly beneath, dark green and sparingly hairy above, elliptic to lanceolate, undulate or with a tendency of being shallowly toothed.

Inflorescence terminal in compact clusters which are cone-shaped; heads sessile and coming out all the way around the axis, woolly throughout; heads densely flowered, green and greenish white; bracts imbricated, outer shorter, numerous; pistillate flowers with a narrow filiform corolla, marginal; staminate flowers with an inflated throat, in the center of the head; pappus capillary.

Plants with prominently winged stems, leaves decurrent, dark green above and white below. In dry and low pinelands with either acid or alkaline soil. S.E.U.S. west to Miss. and north to North Carolina. [Plate XIII, Fig. A.]

29. Gnaphalum L.

Gk. *knaphalon,* a lock of wool, referring to the woolly pubescence.

1. Leaves with more pubescence on the lower surface of the leaf than above, the upper surface green in color.

2. Leaves elliptic, linear, or lanceolate ..... 1. *G. polycephalum*
2. Leaves spatulate ..... 2. *G. spathulatum*
1. Leaves about equally pubescent on both surfaces ..... 3. *G. falcatum*

1. *G. polycephalum* Michx., Fl. Bor. Am. 2: 127. 1803. COMMON EVERLASTING.

Gk. *polus*, many, *kephale*, head. *G. obtusifolium* L.

Herbaceous plants somewhat woody at base, much branched above; stems densely white woolly; leaves alternate, elliptic or sometimes linear or even lanceolate, sessile, apiculate, entire or slightly undulate, revolute, up to 10 cm. long but mostly 5-6 cm. long, less than 1 cm. wide, light green above and with only a few hairs, white woolly or cobwebby tomentose below.

Heads discoid, 7 mm. high, 2 to 4 clustered together and these clusters very numerous all along the many branches; bracts numerous, dry and scarious, in several series, white to greenish-white, obtuse, outer ones pubescent at the base, inner ones glabrous; flowers cream-colored or white, 3-4 mm. long, outer ones pistillate, filiform, inner ones perfect and slightly larger; pappus capillary, the individual bristles easily separated and falling away, achene glabrous.

Low annual plants with conspicuous dense white hairy stems and lower surface of the leaves, but the upper surface a light green in color; leaves with a faint spicy odor; stems much branched above and with numerous small heads, the bracts papery and white in color. Collected on Key Biscayne along the road. Probably a transient and not established. E.U.S. west to Texas and north to Canada. [Plate XIII, Fig. D.]

2. *G. spathulatum* Lam., Encycl. 2: 758. 1786. CUD WEED.

Lat. *spatha*, broad blade.

Low herbs with white cobwebby, rather succulent stems; leaves alternate, sessile or narrowed to a winged petiole, mostly spatulate, entire, up to 7 or 8 cm. long, sometimes undulate, apiculate, light green above and sparingly hairy, white silky and more densely hairy on the lower surface.

Heads very small, clustered in axils of the leaves, discoid; most heads short-peduncled; involucre pubescent, ovoid in shape, bracts

scarious, greenish in center; flowers very narrow, cream-colored, projecting out beyond the involucre; pappus capillary, the bristles united at the base; achene pubescent.

Weedy plants growing in lawns, gardens, cultivated places, roadsides, etc. S.E.U.S. west to Texas and north to No. Car. Haiti, Dominican Republic. [Plate XIII, Fig. B.]

3. *G. falcatum* Lam., Encycl. 2: 758. 1786. CUD WEED.
Lat. *falcis,* a sickle.

Plants resembling *G. spathulatum* but more slender and little branching, stems and both surfaces of the leaves about equal in the amount of tomentose pubescence, or the stem may be more hairy and occasionally the upper part of the leaves may have less pubescence; leaves linear or linear-spatulate; heads about 3 mm. long, in terminal and axillary clusters.

Pinelands and waste places in about the same habitats as the preceding species. S.E.U.S. west to Texas and north to Tenn. South America. [Plate XIII, Fig. C.]

30. BERLANDIERA DC.

Named for J. L. Berlandier, 1805-1855, a Swiss botanist who collected in Mexico and Texas.

1. *B. subacaulis* Nutt., in Trans. Am. Phil. Soc. Ser. II. 7: 343. 1841. FLORIDA DANDELION, GREEN EYES
Lat. *sub,* somewhat, *a,* absent, *caulis,* stem.

Low herbaceous, tufted plants branching near the base; stems brown hairy; leaves alternate, up to 2 dm. long and 3 cm. wide, oblanceolate, lyrate pinnatifid or lobed, the lobes mostly rounded and entire or sometimes toothed, rough hairy, basal leaves petioled, stem leaves sessile.

Heads terminal on long peduncles, 2½ to 3 cm. in di., showy, radiate; bracts large, imbricated in 3 series, as broad as long, the inner ones longer and exceeding the disk flowers, pubescent; rays about 6 to 10, bright yellow, fertile; disk flowers yellow, sterile; pappus absent; heads chaffy, the chaff pubescent, subulate, partially enclosing the abortive ovaries of the disk flowers; achenes flat, pubescent, produced only by the ray flowers and more or less

adherent to the large broad inner bracts of the involucre and falling with them.

Very attractive plants with showy yellow heads. Found only in dry pinelands throughout Florida. The range in our area is very peculiar; plants can be found in Broward County and Dade County as far south as north Miami, then the range jumps all of south Miami and Coral Gables and the plants are found again several miles south of greater Miami. [Plate XIII, Fig. E.]

31. Parthenium L.

Gk. *parthenos,* virgin, only the pistillate flowers fertile.

1. *P. hysterophorus* L., Sp. Pl. 988. 1753. RAGWEED.
Gk. *hystera,* womb, *phorus,* bearing.

Low, weedy, annual herbs; leaves alternate, pubescent, lower leaves petioled, irregularly lobed, incised or pinnatifid, ovate in outline, resembling leaves of *Ambrosia elatoir.*

Heads radiate, 5-6 mm. in di.; involucre of about 5 bracts, saucer-shaped, pubescent; rays small, white, inconspicuous, 5 in number, giving the head a star-shaped appearance, fertile; disk flowers very dense, white-cottony, sterile; pappus absent; heads chaffy; achenes flat, produced only by the ray flowers and adhering to 2 or 3 bracts and falling with them.

A weed of roadsides, cultivated places, etc., with small, white star-shaped heads and ragweed-like leaves. Often used as a filler in florists' bouquets. More or less sporadic in Miami area but common in Key West. E.U.S. west to Texas and Mo. and north to Mass. Throughout the West Indies, Central America and South America. [Plate XV, Fig. F.]

32. Eclipta L.

Gk. *ekleipo,* to be deficient, referring to the absence of the pappus.

1. *E. alba* (L.) Hassk., Pl. Jav. Rar. 528. 1848.
Lat. *albus,* white. *Verbesina alba* L.

Annual, weedy, erect or more or less decumbent, branching herbs; leaves opposite, sessile, acute, lanceolate, coarsely or sparingly toothed, up to 7 and 8 cm. long, pubescent.

Heads radiate, peduncled, in axils of leaves, up to 1 cm. wide, not too showy; involucre campanulate, bracts in two series, green, ovate, pubescent and ciliate; receptacle a broad dome, chaffy with hair-like or bristle-like chaff; rays numerous, resembling a white

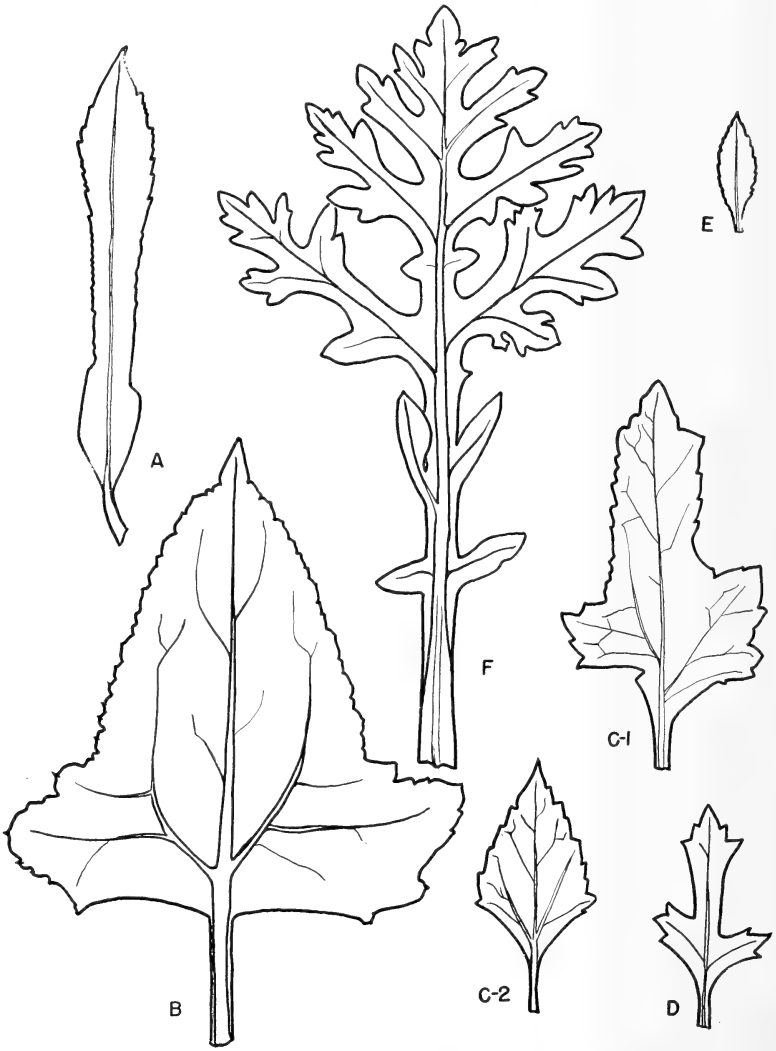

Plate XV. A. *Melanthera angustifolia.* B. *Melanthera deltoidea.* C-1 and C-2. *Melanthera radiata.* D. *Melanthera parviflora.* E. *Spilanthes repens.* F. *Parthenium hysterophorus.*

fringe; pappus absent; achenes 3-4 sided, white warty, small, green on top, being very conspicuous on the receptacle after the flowers have fallen away.

Mostly in wet or moist places along stream banks and in waste places. Essentially a tropical plant found throughout the West Indies, Mexico, Central America, and South America; in E.U.S. west to Texas and New Mexico, north to Neb. and Mass. Also in Africa, Australia and East Indies.

In the Orient the plants are used medicinally — internally as a purgative, externally for skin diseases. Also prepared with coconut oil and rubbed into the hair to make it grow and keep it black. The leaves are cooked and eaten as a vegetable. [Plate XIII, Fig. J.]

33. Melanthera Rohr.

Gk. *melas,* black, *anthos,* flower, referring to the black anthers.

More or less weedy, somewhat aromatic, coarse herbs of pinelands, roadsides, and waste places, with many branches, some species often forming a dense, low growth, others quite tall and shrub-like; roots woody and thick; leaves opposite, short-petioled, mostly coarsely serrate or sometimes entire and occasionally hastate, scabrous, rough to the touch, prominently veined. Heads discoid, on rather long peduncles; involucre imbricated in 2 or 3 series with broad bracts; flowers white to pinkish with prominent black anthers; pappus of 2 weak, deciduous awns; heads chaffy, the chaff often purple-tipped.

1. Leaves narrow, oblanceolate to linear, not lobed ..... 1. *M. angustifolia*
1. Leaves ovate in outline, usually some leaves on the plant that are definitely lobed.
   2. Leaves mostly over 5 cm. long and at least some leaves with 2 short lobes below the middle and the central lobe usually long and prominent ..... 2. *M. deltoidea*
   2. Leaves less than 5 cm. long.
      3. Leaves not lobed, ovate; or if lobed the central lobe broad, obovate ..... 3. *M. radiata*
      3. Leaves mostly lobed, the central lobe very narrow and mostly spatulate in outline ..... 4. *M. parviflora*

1. *M. angustifolia.* A. Rich., Fl. Sagra. Cub. 2: 54. 1850.
Lat. *angustus,* narrow, *folium,* leaf.

Low plants with few branches, or sometimes if growing around

hammocks or mangrove areas large bushy plants with many branches; stems hairy, square, often with purple-red lines or entirely red-purple; leaves wedge-shaped, oblanceolate, linear, or spatulate, from 2 to 10 cm. long but seldom over 1 cm. wide, acute, scabrous, dentate to serrate or entire. Bracts acute, 4-5 mm. long; heads 2½ cm. in di.

This species of *Melanthera* has very narrow leaves, none of which are lobed. Mostly in low places such as glades, prairies, around hammocks, edges of mangrove swamps but often in dry pinelands. Sometimes growing into large spreading bushes, especially at Matheson Hammock and in the everglades; in pinelands a low spreading plant. Southern Florida and the Keys. Dominican Republic. Cuba (?). [Plate XV, Fig. A.]

2. *M. deltoidea* Michx., Fl. Bot. Am. 2: 107. 1803.
Gk. *deltoidea,* triangular.

Plants much branched; stems square, sometimes purple, scabrous; leaves mostly ovate, sometimes deltoid, most always with two lower lobes, hastate, 5-12 cm. long, acute or obtuse, crenate or serrate, scabrous. Bracts 3-5 mm. long, obtuse, acute, or short acuminate, not long pointed.

A common, weedy plant, often growing in large masses; in waste places, roadsides, etc., common near the coast from Ft. Lauderdale to the Sand Keys. The leaves are the largest of our Melantheras and almost always with 2 basal lobes. Southern Florida and the Keys. Bahamas, Cuba, Dominican Republic, Jamaica, Trinidad, Mexico, Yucatan, Costa Rica. [Plate XV, Fig. B.]

3. *M. radiata* Small, Bull. Torr. Bot. Club. 34: 163. 1909.
Lat. *radiatus,* rayed, referring to the radiating branches.

Low bushy plants with several stems radiating out from near the base of the plant; leaves usually less than 5 cm. long, ovate to lanceolate, hastate or not, if lobed the central lobe broad and widest above the middle, obovate; lateral lobes short, obscure, absent, or very prominent; leaves coarsely serrate or sometimes entire, acute or obtuse, central lobe if present definitely serrate. Bracts 4-6 mm. long, obtuse.

The most common species in our pinelands; low growing plants with thick, woody roots, many short branches radiating out from

the base, and mostly ovate, lobed leaves, but the leaves varying considerably in shape. Confined to southern Florida and the Keys. [Plate XV, Fig. C.]

4. *M. parviflora* Small, Fl. S.E.U.S. 1251. 1903.
Lat. *parvos,* small, *florus,* flower.

Leaves only 2 to 3 cm. long, hastate, the central lobe very narrow, contracted below the middle to give a spatulate shape, the tip of the central lobe coarsely toothed, but entire below the middle, or finely serrate; the lateral lobes sometimes as narrow as the central lobe but more often broader. Bracts 5-7 mm. long, acute.

Plants resembling *M. radiata* but the leaves smaller and narrower. Not as common. In pinelands and near the coast. Southern Florida and the Keys. [Plate XV, Fig. D.]

M. ligulata Small, Fl. S.E.U.S. 1251. 1903. Resembles *M. angustifolia* but differs in the length of the leaves — *M. ligulata* has leaves that are up to 16 cm. long, narrowly linear, more evenly toothed; the bracts are longer than the disk flowers, 10 to 12 mm. long, pointed. Collected by Small in the pinelands of Ft. Lauderdale. I have not been able to find this species in this area.

M. hastata Michx., Fl. Bor. Am. 2: 107. 1803. Leaf blades 8 to 15 cm. long; bracts and chaff long acuminate making the head rather prickly to the touch; bracts 8 to 10 mm. long. In damp soil along shores, streams, etc. Fla. to La. and So. Car. Resembles *M. deltoidea* and may be found in our area.

34. Spilanthes Jacq.

Gk. *spilos,* a stain, *anthos,* a flower, referring to the yellow flowers.

1. *S. repens* (Walt.) Michx., Fl. Bor. Am. 2: 131. 1803.
Lat. *repens,* creeping. *S. americana* (Mutis.) Hier.

Stems weak or reclining or loosely ascending, somewhat succulent, usually with purplish or reddish color, glabrous or rarely white hairy; leaves opposite, short-petioled or narrowed to a sessile base, entire or serrate, somewhat thickened, glabrous or occasionally pubescent especially below, varying in shape from ovate to lanceolate or sometimes linear, up to 2 or 3 cm. long, rarely longer, and 1-2 cm. wide.

Heads peduncled, the peduncles up to 6 or 10 cm. long, glabrous or white hairy; heads radiate, up to 15 mm. wide; involucre campanulate, bracts in few series, minutely hairy, acute or acuminate; receptacle cone-shaped, elongating as the achenes mature; heads chaffy, the chaff usually orange-tipped, enclosing the achenes; ray flowers not numerous, 10 or less in number, but sometimes 15 to 20, yellow, conspicuously 2 or 3 lobed; disk flowers orange-yellow, lobes short and spreading; pappus absent.

Attractive plants when massed together, the small cone-shaped heads a bright yellow or orange. Recommended for a ground cover in shady places in the yard. Found mostly in low ground — in the glades and everglades and cypress swamps west and south of Miami; often forming extensive mats on the floor beneath the cypress trees. S.E.U.S. west to Texas and Mo., north to No. Car. Dominican Republic, Cuba (?), Yucatan, Costa Rica. [Plate XV, Fig. E.]

35. Rudbeckia L.

Named for Professors Olaf Rudbeck, father (1630-1702) and son (1660-1740), Linnaeus' predecessors at Upsala.

1. *R. hirta* L., Sp. Pl. 907. 1753. BLACK-EYED-SUSAN.
Lat. *hirsutus*, rough hairy.

Low plants with basal leaves forming more or less a rosette; leaves alternate, rough hairy with short, white hairs, coarsely serrate; basal and lower leaves 3-veined, long petioled, petiole sometimes winged; stem leaves sessile, slightly clasping, some stem leaves with a winged petiole elliptic to lanceolate or oval.

Heads radiate, 5-8 cm. in di., terminal, on long solitary peduncles; involucre flat, spreading, bracts in several series, broad, spatulate, scabrous, inner ones lanceolate, acuminate; receptacle conic, elongated; chaff purple-tipped, subulate; ray flowers showy, up to 2½ and 3 cm. long, yellow; disk flowers dark purple-brown, very numerous; pappus absent.

The black-eyed-susans are well known to most people, the "black-eye" being the dark-colored disk flowers. This species seems to be moving south. It has been collected only recently along the Tamiami Trail about 40 miles west of Miami. It is fairly common from Naples northward. E.U.S. west to Okla. and north to Canada.

Used by the Seminoles for treating fevers and headaches. [Plate XVI, Fig. C.]

Plate XVI. A. *Borrichia frutescens.* B. *Borrichia arborescens.* C. *Rudbeckia hirta;* 1. basal leaf, 2. stem leaf. D. *Tithonia diversifolia.* E. *Calyptocarpus vialis.*

36. Wedelia Jacq.

Named for George Wolfgang Wedel, 1645-1721, Professor at Jena.

1. *W. trilobata* (L.) Hitch., Rep. Mo. Bot. Gard. 4: 99. 1893.
Lat. *tri,* three, *lobatus,* lobed.

Sprawling vines or diffusely branched and creeping herbs; leaves opposite, thick scabrous, short-petioled, the petiole sometimes winged, connate, acute, ovate in outline with 2 lobes below the middle making a 3-lobed leaf, margins dentate or coarsely toothed with minute dark tips.

Heads radiate, up to 3 cm. in di., peduncled; bracts of the involucre in 2 to 3 series, all bracts more or less equal or the outer ones longer, foliacious, pubescent; ligules yellow, 3-toothed, pistillate; heads chaffy, the chaff dark-tipped; pappus a crown of several scales united into an irregular shaped cup.

Wedelia is native to the West Indies and Central America. It has been introduced and planted in the garden as a ground cover in the shade; the yellow heads are very showy. It has escaped into pinelands and roadsides in the Miami area. [Plate XVIII, Fig. E.]

37. Borrichia Adans

Named for Ole Borrich, 1626-1690, a Danish botanist.

1. Bracts of the involucre reflexed; the bracts and chaff spine-tipped ..... 1. *B. frutescens*
1. Bracts of the involucre appressed; the bracts and chaff not spine-tipped ..... 2. *B. arborescens*

1. *B. frutescens* (L.) DC., Prod. 5: 489. 1836. sea-ox-eye-daisy.
Lat. *frutex,* shrub, *escens,* slightly.

More or less low, shrubby plants; leaves opposite, thick, 3-nerved, spatulate, obovate, or sometimes linear, sessile or narrowed to a winged petiole, clasping, apiculate or mucronate with a short minute spine, mostly entire or sometimes with the lower half of the leaf serrate and occasionally with 2 or several ear-like projections near the base or on the lower part of the leaf, gray-green in color with many small appressed soft hairs, or old plants and plants

growing in the shade with leaves that are glabrous and appearing light green in color.

Heads radiate, up to 3-4 cm. in di., terminating the branches on peduncles which are up to 7 or 8 cm. long; rays yellow and conspicuous; bracts imbricated in 2 or 3 series, reflexed, especially the outer ones, the inner ones erect, stiff; all bracts thick and leathery with stiff spines on the tips; chaff present and spine-tipped, together with the spine-tipped bracts they make the head prickly when touched; pappus a crown of scales; achenes 4-angled, black. When the ligules and disk flowers fall away the achenes are left imbedded in the thick spine-tipped chaff.

Attractive, low shrubs with apple-green or silvery thick leaves and large yellow heads. Typical of salt marshes, edges of mangrove swamps and buttonwood hammocks, and sometimes sandy shores along or near the coast. More common than the next species. S.E.U.S. west to Texas and north to So. Va. Bermuda, Mexico, Yucatan. [Plate XVI, Fig. A.]

2. *B. arborescens* (L.) DC. Prod. 5: 489. 1836. SEA-OX-EYE-DAISY.
Lat. *arbor,* tree, *escens,* slightly.

Resembling *B. frutescens* and often growing with it but not nearly as common. It differs in the following respects: leaves with one main vein and many lateral veins which appear to run parallel to the midrib, apiculate to acute, most always entire, up to 15 cm. long but usually about 6 cm. long, more often glabrous than pubescent. Outer bracts much larger, appressed and not reflexed, inner bracts rounded, upper part of bract papery; bracts and chaff not spine-tipped, the heads not prickly to the touch; chaff merely acute or obtuse, not leathery, herbaceous.

In salt marshes of southern Florida and the Keys. Found throughout the West Indies and Central America. [Plate XVI, Fig. B.]

38. TITHONIA Desf.

Named for *Tithonus,* favorite of Aurora, goddess of Dawn, in allusion to the orange rays of some species.

1. *T. diversifolia* (Hemsl.) Gray, in Proc. Amer. Acad. 19: 5. 1883. MEXICAN SUNFLOWER.
Lat. *diversus,* various, *folium,* leaf.

Tall shrubby perennials with woody stems and many branches; stems pubescent, sometimes woolly, striate; leaves large, alternate, 3-5 lobed or deeply parted and with 3 main veins, tapering to a winged petiole, margins serrate to dentate, scabrous above, whitish beneath, all lobes acute to acuminate.

Heads large and showy, up to 10 cm. in di., on long peduncles which are swollen just below the head; involucre broad campanulate, the bracts in 2 series, the outer shorter and appressed, the inner longer and somewhat spreading at the tips; ligules bright yellow, neutral, 2-3 parted at the apex, 12-14 in number; disk flowers yellow, lobes erect; heads chaffy, the chaff surrounding the achenes; pappus of 2 small scales, one on each side, and several erose-tipped scales which are shorter and borne all around the ovary; achene 4-angled, pubescent at least when young; flowers fragrant.

A cultivated plant native to Mexico and also found throughout the West Indies and Central America. Escaped and well established along roadsides, in fields, waste places, and pinelands, often forming large growths in pinelands and roadsides of the Miami area, the large yellow heads are very conspicuous and showy. [Plate XVI, Fig. D.]

39. Helianthus L.

Gk. *helios,* sun, *anthos,* flower.

1. *H. debilis* Nutt., in Trans. Am. Phil. Soc. n.s. 367. 1841. BEACH SUNFLOWER.

Lat. *debilis,* weak.

Decumbent herbs with a sticky juice; stems hispid, much branched, the branches borne more or less horizontally on the ground; leaves opposite, or alternate above, long petioled, scabrous, irregularly serrate or dentate, deep green in color, deltoid to ovate, acute, base cuneate to cordate, blades up to 8 or 10 cm. long and 6 cm. wide but mostly smaller, 3-veined.

Heads radiate, showy, up to 6 cm. in di., on long peduncles, the the peduncles up to 12 cm. long, hispid; receptacle dome-shaped; bracts of the involucre in several series, spreading, long acuminate, red-tipped, scabrous, ciliate; ligules yellow, sterile, up to 2 cm. long and 1 cm. wide; disk flowers yellow with dark purple lobes;

chaff acuminate, enclosing the achenes; stamens, styles, tips of the chaff, and the lobes of the disk flowers a dark purple; pappus of 2 small, obscure, scale-like awns; achenes black, hairy.

Plate XVII. A. *Verbesina laciniata.* B. *Actinospermum angustifolium.* C. *Coreopsis Leavenworthii;* 1. compound leaf, 2. simple leaf, 3. var. *Garberi.*

Typical plants of the beach, sand dunes, and sandy places near the coast, with prostrate stems, scabrous leaves, and large showy yellow heads with a purple center. Introduced inland and often cultivated. S.E.U.S. west to Texas and north to Georgia. Bermuda. Apparently not found on the Florida Keys. [Plate XVIII, Fig. C.]

Helianthus annuus L., the common cultivated sunflower, is sometimes seen in pinelands around Miami as an escape.

40. Verbesina L.

Name metamorphosed from *Verbena*.

1. *V. laciniata* (Poir.) Nutt., Gen. Am. 2: 170. 1818. CROWN BEARD.
Lat. *lacinia,* torn edge. *Phaethusa laciniata* (Poir.) Small.

Tall, branching, herbaceous plants often with semi-woody stems; stems pubescent, winged; leaves alternate, scabrous with very short hairs, decurrent on the stem for a long distance ending just above the leaf below making the stem winged, sessile, ovate in outline, irregularly lobed or deeply toothed (pinnatifid), the upper leaves usually entire and much reduced, the lower ones 15-20 cm. long or sometimes longer.

Heads radiate, numerous, clustered at ends of branches in corymbs; bracts imbricated, the outer shorter and green-tipped, the inner longer and not green-tipped, hairy; heads 1½-2 cm. in di.; ray flowers fertile, ligules 3-toothed, white, 2 to 6 in number; heads chaffy; pappus of 2 awns; achenes broadly winged.

Tall plants with conspicuous winged stems, lobed leaves, and white heads. Found mostly in waste places, fields, roadsides, in and around hammocks, and sometimes in pinelands. S.E.U.S. north to South Carolina. [Plate XVII, Fig. A.]

2. *V. virginica* L., Sp. Pl. 901. 1753. CROWN BEARD.
Phaethusa virginica (L.) Small.

Resembling *V. laciniata,* but none of the leaves are pinnatifid or lobed, the margins wavy or irregularly toothed; leaves more oval and thinner. Heads larger, over 2 cm. in di. Same habitat as *V. laciniata.* E.U.S. west to Tex. and north to Pa.

41. Calyptocarpus Less.

Gk. *kalyptos,* hidden, *karpos,* fruit.

1. *C. vialis* Less., Syn. Comp. 221. 1832.
Lat. *vialis,* of or belonging to the highways or roads.

Low creeping herbs; stems pubescent; leaves opposite, up to 2-2½ cm. long, serrate, deltoid or ovate, petioled, pubescent and rough to the touch, base cuneate, tip acute.

Heads radiate, small, in axils of the leaves or more or less terminal, short-peduncled; involucre of 4 bracts almost as long as the rays, in 2 series; bracts green, pubescent, mostly long pointed, appressed; receptacle chaffy; rays 4 to 6 in number, yellow; disk flowers few; pappus of 2 awns.

Weedy plants found growing in lawns and in grassy places along streets and boulevards in the Miami area. Mostly depressed plants but if allowed to grow they become erect to 1½ feet. Heads small, yellow, almost hidden by the leaves. Apparently of recent introduction in this area, not previously reported. S.E.U.S. west to Texas. Cuba, Mexico, Salvador. Costa Rica. [Plate XVI, Fig. E.]

42. Coreopsis L.

Gk. *koris,* a bed bug, *opsis,* aspect, from the appearance of the achenes.

1. Stems leafy, all leaves opposite, simple or compound; heads numerous, inflorescence usually much branched; heads less than 5 cm. in di.
   2. All leaves very narrow, under 5 mm. wide ..... 1. *C. Leavenworthii*
   2. Basal leaves 5 mm. to 1½ cm. wide .... 2. *C. Leavenworthii* var. *Garberi*
1. Main leaves basal, these 1-2 cm. wide; stem leaves few, distant, mostly alternate; all leaves simple; heads 5 cm. or more in di., solitary ..... 3. *C. gladiata*

1. *C. Leavenworthii* T. & G., Fl. No. Am. 2: 346. 1841. tickseed.
Named for Dr. M. C. Leavenworth, a southern botanist of the last century.

Slender plants often with many branches from the lower nodes, glabrous throughout; leaves opposite, entire, thickish, linear or oblanceolate, up to 16 or 20 cm. long, becoming smaller toward the top of the plant, the upper leaves very small and almost scale-like; the lower leaves may all be simple, that is, with no divisions, or in

some plants the lower leaves may be compound with 2 to 6 divisions, all divisions linear and only 2-4 mm. wide. The internodes of some plants, especially tall plants, may sometimes be very long, often much longer than the leaves.

Heads radiate, showy, less than 5 cm. in di. on long peduncles, in open corymbs; involucre of 2 or 3 series of bracts, the outer scale-like and green, 1 mm. or less in length, the inner series longer, 4 mm. long, deltoid or oval, scarious, yellowish; ligules broad, bright yellow; disk flowers dark brown; heads chaffy; achene oval, body elliptic, each wing as broad as the body, 3 mm. long; pappus of 2 awns. [Plate XVII, Fig. C-1 and C-2.]

2. *C. Leavenworthii* var. *Garberi.* Lower leaves broad, over 5 mm. wide, often 1 or 2 cm. broad; leaves simple or divided with 2 to 4 divisions, the divisions broad; inner bracts 1 cm. long.

Both the species and the variety are rather showy plants with long, slender stems, bright yellow rays and dark brown disk flowers. Found in low pinelands, glades, prairies, roadsides; rarely in dry pinelands. Southern Florida and the Keys, north to about the middle part of the state. The Seminole Indians use this plant in treatment for heat prostrations. [Plate XVII, Fig. C-3.]

3. *C. gladiata* Walt., Fl. Car. 211. 1788.
Lat. *gladius,* sword.

Herbaceous plants, glabrous throughout; main leaves basal, erect or somewhat spreading, petioled, blade up to 10 cm. long, obtuse or acute, entire, thick and fleshy, veins obscured, conspicuously punctate, spatulate; stem leaves opposite or frequently alternate, few in number and widely separated, thick and fleshy, almost linear, 5 cm. or less in length.

Heads radiate, large, 5 cm. in di., long peduncled, solitary or with 1 or 2 forking branches; involucre of 2 series of bracts; the outer small (2 mm.), spreading, red-tipped; inner bracts longer (10 mm.), red-veined, erect but tips spreading; rays bright golden yellow, 3 lobed, the terminal lobe notched; disk flowers deep purple; heads chaffy, the chaff red-tipped; anthers and stigmas deep purple-black; achene 4-5 mm. long, dark purple-black, with erose or dissected margins; pappus of 2 small erect awns.

Attractive plants with large yellow and purple heads and thick basal leaves. This and the preceding species have 8 ray flowers, 8 small outer bracts, and 8 larger inner bracts. Found on margins of pinelands and everglades in damp sandy marl, west of Miami. Not as common as *C. Leavenworthii.* Sporadic, appearing in the fall only ofter a wet summer, and absent if the summer has been dry. S.E.U.S. north to North Carolina and west to Miss.

43. Bidens L.

Lat. *bi,* two, *dentis,* toothed, referring to the two awns of the achene.

1. *B. leucantha* L., Sp. Pl. 832. 1753. SHEPHERDS NEEDLES.
Gk. *leukos,* white, *anthos,* flower. *B. pilosa* L.

Weedy herbs with 4-angled stems, sometimes woody at base, often red-tinged; leaves opposite, compound with 3-7 divisions, or simple on upper part of the plant, petioled with the base clasping; leaflets lanceolate to ovate, acute to acuminate, glabrous, up to 6 cm. long, margins dentate to serrate.

Heads radiate, up to 2 or 3 cm. in di., peduncled; involucre broadly campanulate, bracts in 2 series, the outer bracts with bases united and the green tips spreading, the inner series longer and paler; rays white, showy, few, sometimes absent, occasionally red-veined, 2 to 3 lobed; disk flowers yellow, numerous; heads chaffy; pappus of 2 barbs.

The most conspicuous plant in south Florida; found along almost all roadsides, sidewalks, railroad tracks, and in pinelands, cultivated areas, waste places, fields, edges of hammocks, etc. The attractive white rays are quite conspicuous, and the achenes that stick to the clothing by the barbed awns make this plant quite annoying when one walks through a field of these plants. One of the first plants to be affected by the frost. Mostly confined to Florida but occasionally found in southern Georgia and Alabama. California. Has appeared as an occasional weed as far north as Mass. Throughout the West Indies, Mexico, Central America, South America, Pacific Islands, East Indies, Hawaii, Africa. [Plate XVIII, Fig. A.]

Bidens Nashii Small has been collected by Buswell in the Everglades of Collier County. Leaves somewhat fleshy, opposite, sessile,

connate, clasping, entire or finely serrate; heads large and showy, the ligules yellow; heads 4-5 cm. in di. Ranges from Florida to Texas.

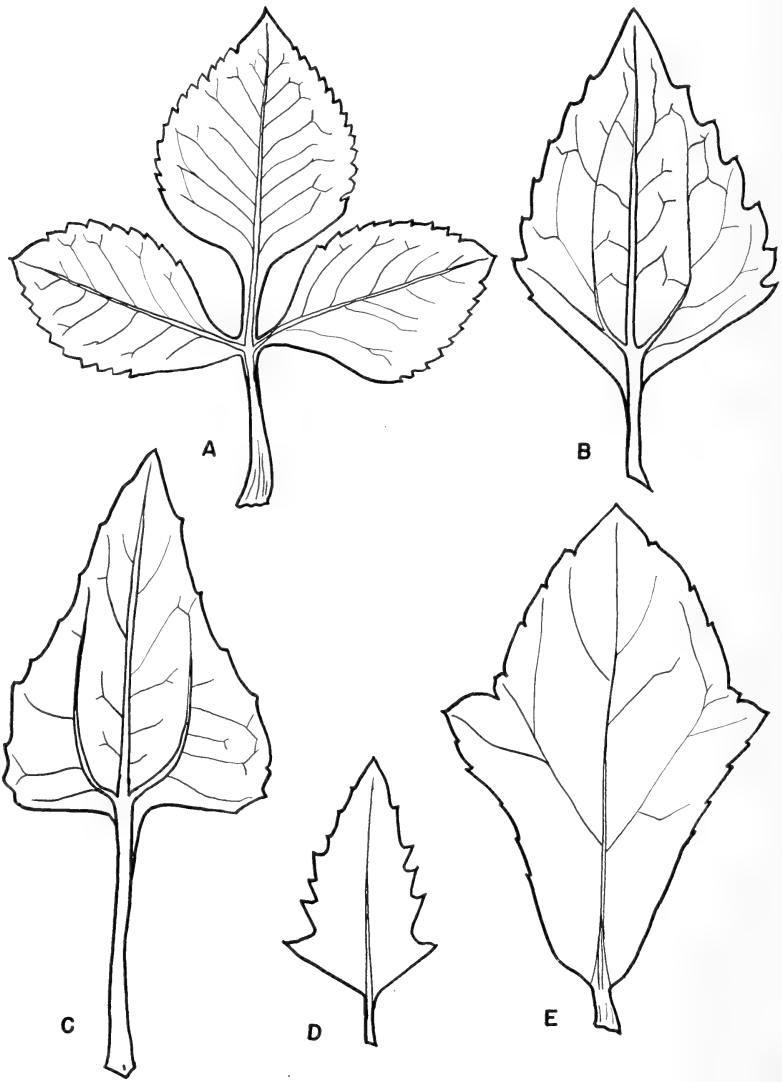

Plate XVIII. A. *Bidens leucantha.* B. *Galinsoga ciliata.* C. *Helianthus debilis.* D. *Tridax procumbens.* E. *Wedelia trilobata.*

44. Actinospermum Ell.

Gk. *aktinos,* a ray, *sperm,* seed, probably from the appearance of the mature heads.

1. *A. angustifolium* (Pursh.) T. & G., Fl. No. Am. 2: 389. 1841. YELLOW BUTTONS.

Lat. *angustus,* narrow, *folium,* leaf.

Often rather tall herbs with many branches from the base of the plant and loosely branched above; stems partly woody near the base, green above, glabrous, grooved; leaves alternate, linear, very narrow, numerous, acute, entire, thickish, midvein depressed in center of the leaf, glabrous, punctate, up to 5-8 cm. long.

Heads radiate, showy, terminal, up to 5 cm. in di.; involucre flat, bracts narrow, in several series, reflexed or spreading, thick, green, triangular, outer acute, inner acuminate; disk conical, honeycombed, pits of the honeycombed receptacle with thin margins; disk chaffy, irregularly cut, erose; ray flowers with ligules 2 cm. long, lemon yellow, sterile, deciduous, 3-4 lobed or toothed; disk flowers yellow, fertile; pappus of several small membraneous scales, not conspicuous; achenes embedded in the pits of the receptacle, very small, pointed at the base.

Attractive plants with numerous, narrow leaves and large, yellow heads. Found in sandy acid soil of the scrub lands and pinelands; more common further north but also found in the acid sand pockets around Miami as far south as Chapman Field. S.E.U.S. to Miss. and Georgia. [Plate XVII, Fig. B.]

45. Tridax L.

Lat. *tri,* three, *dentis,* tooth, from the three toothed or lobed rays.

1. *T. procumbens* L., Sp. Pl. 900. 1753.

Gk. *pro,* forward, Lat. *cumbens,* lying down.

Low, more or less decumbent, sprawling, branching herbs with brittle, hairy stems; leaves opposite, pubescent, simple, irregularly or coarsely toothed, occasionally tending to be 3-lobed, up to 6 cm. long, sessile or short-petioled, base clasping, acute to acuminate, lanceolate to ovate.

Heads radiate, on long erect peduncles which may be up to 20 cm. long; bracts in 2 series, outer green and foliacious, inner more

like the chaff; bracts united at the base, equal in length, pubescent, heads chaffy, the chaff purple-colored at the tip; ligules usually 5 in number, white to cream-colored or yellowish, prominently 3-lobed or toothed; pappus plumose.

A common, low growing weed with coarse leaves and cream-colored heads at ends of long stalks; growing in lawns, waste places, roadsides, cultivated areas, pinelands, etc. Southern Florida and the Keys. Native of West Indies, Mexico, Central America, South America. Hawaii. In Hawaii the leaves are used as an insecticide. [Plate XVIII, Fig. D.]

46. Galinsoga R. & P.

Named for Dr. Mariana de Galinsoga, Supt. of the Botanic Gardens in Madrid, Spain, in the 18th century.

1. *G. ciliata* (Raf.) Blake, Rhodora, 24: 35. 1922.
   Lat. *cilia,* fine hairs. *G. parviflora* Cav. var. *hispida* DC.

Annual, weedy herbs usually much branched, the stems more or less decumbent; stem pubescent with long white hairs; leaves opposite, petioled, up to 7 cm. long, lanceolate to ovate, serrate, pubescent, petiole connate forming a line at the node.

Heads radiate, on peduncles up to 2-3 cm. long, in axils of the leaves; heads 4-5 mm. high, up to 5 mm. in di.; bracts and peduncles covered with white hairs with gland tips; involucre bracts in 2 rows, outer ovate; rays 4 to 5, broad, white, 3-lobed, ligule 1½ to 2 mm. long; disk flowers yellow, lobes erect; pappus of several bristles or scales which have an erose margin; receptacle conical, chaffy.

Collected recently by Curtis Jackson, former student in botany at the University of Miami, in N. W. Miami. Apparently *Galinsoga* is of recent introduction and has not become well established in this area yet. It is a common weed throughout most of the United States and Canada. Native of South America and found throughout the West Indies, Mexico and Central America, Hawaii. Somewhat used as a potherb. [Plate XVIII, Fig. B.]

47. Helenium L.

Named for *Helena,* Helen of Troy.

1. Main leaves basal forming a rosette; leaves spatulate to elliptic ---------- 1. *H. vernale*

1. Stems leafy.
   2. Stems winged by the decurrent leaves; leaves not filiform or linear ---- 2. *H. nudiflorum*
   2. Stems not winged by the decurrent leaves; leaves linear to filiform ---- 3. *H. tenuifolium*

1. *H. vernale* Walt., Fl. Carol. 210. 1788. MARSH SNEEZE WEED.

Lat. *vernalis,* belonging to spring.

Main leaves basal, forming a rosette; leaves elliptic to linear and spatulate, glabrous, punctate, thickish, entire or distantly serrate, sessile or short-petioled, up to 20-30 cm. long; stem leaves sessile, clasping, distantly serrate, glabrous, becoming progressively smaller, the upper leaves reduced to scales.

Heads terminal and solitary on ends of the scapes which arise from the center of the rosette, scape up to 10 dm. high; heads radiate, yellow, up to 4 or 5 cm. in di.; involucre of many bracts which are borne more or less horizontally, the outer ones brown or dark purple-brown, the inner ones green with dark tips; ligules conspicuous, hairy on outer surface, wedge-shaped, 3-lobed or toothed; pappus of several silvery scales which are minutely awned or erose.

Attractive plants with large basal leaves and a single stalk bearing a large yellow head; flowering in the spring and early summer months. Found in the everglades and wet prairies. S.E.U.S. north to Miss. and North Carolina. [Plate XIX, Fig. A.]

2. *H. nudiflorum* Nutt., Trans. Am. Phil. Soc. (II) 7: 384. 1841. PURPLE SNEEZE WEED.

Lat. *nudus,* bare, *floris,* flower, referring to the occasional lack of ray flowers.

Stems erect, scabrous, conspicuously winged by the decurrent leaves; leaves alternate, sessile, distant, becoming smaller upward; lower leaves toothed, upper leaves entire; blades punctate, scabrous, acute, decurrent, lower leaves to 6 cm. long, 1 cm. wide, oblanceolate; stem leaves 4 cm. long or smaller, lanceolate to linear, becoming scale-like in inflorescence.

Inflorescence corymbose; heads radiate or discoid, at ends of long peduncles, 1½-2 cm. in di., or only 1 cm. in di. in discoid heads; receptacle elongated forming a globose head; bracts of involucre spreading, eventually recurved, 8 mm. long; rays yellow or brownish,

10 to 15 in number, 3 lobed, becoming recurved, may be absent; disk flowers numerous, brownish or dark purple-red; pappus of silvery scales.

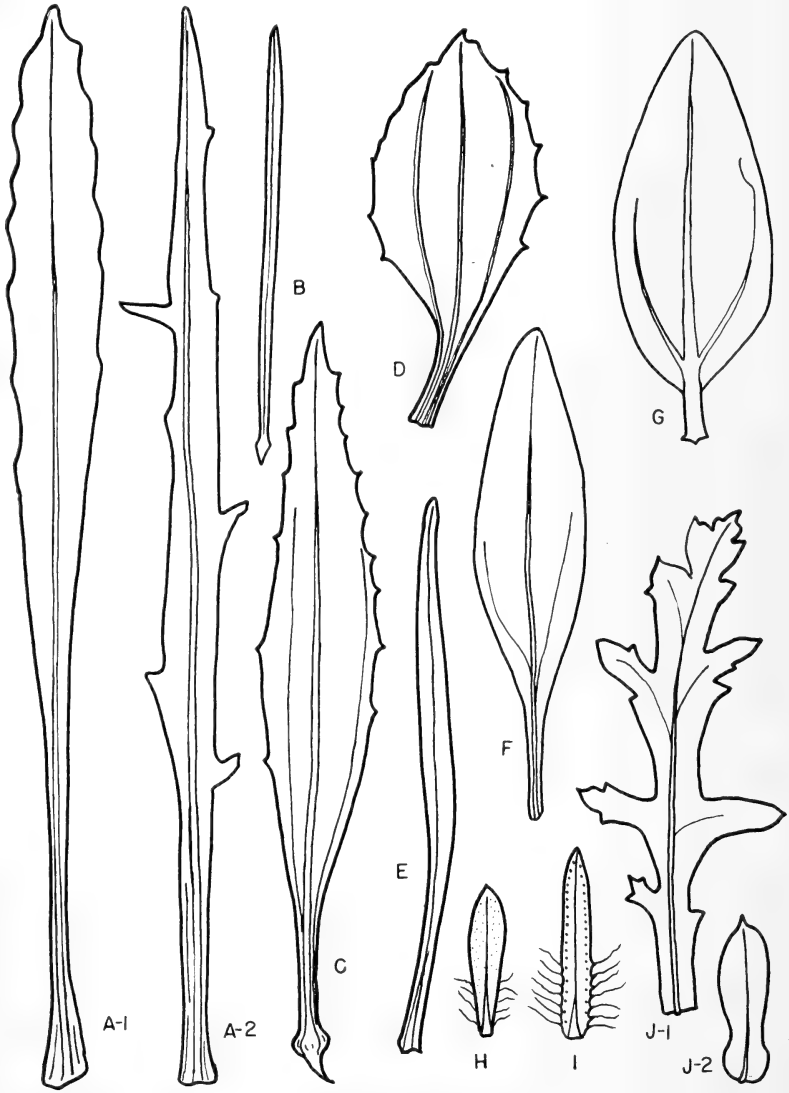

Plate XIX. A-1 and A-2. *Helenium vernale.* B. *Helenium tenuifolium.* C. *Flaveria floridana.* D. *Flaveria trinerva.* E. *Flaveria linearis.* F. *Polypteris integrifolia.* G. *Palafoxia Feayi.* H. *Pectis prostrata.* I. *Pectis leptocephala.* J-1 and J-2. *Gaillardia pulchella* var. *picta.*

Not common in our area. Collected by Mr. Woodbury on Long Pine Key in low ground. Easily recognized by the winged stems; the heads brownish-red in color, with or without rays. E.U.S. north to Conn., Ill., Mo., and west to Texas.

3. *H. tenuifolium* Nutt., in Jour. Acad. Phil. 7: 66. 1834. SPANISH DAISY.

Lat. *tenuis,* thin or slender, *folium,* leaf.

Herbaceous plants resembling Actinospermum, glabrous throughout; leaves alternate, very narrow, linear or almost filiform, numerous, entire, punctate, sessile, up to 8 or 10 cm. long but mostly smaller, and mostly less than 5 mm. wide.

Heads radiate, showy, about 2-4 cm. in di.; bracts in 1-2 series, linear, spreading; receptacle conic, naked; rays cuneate, yellow, 3-lobed; disk flowers yellow; pappus of several silvery scales, awn-tipped; achene silvery hairy.

This plant is easily identified by the numerous, small leaves and the large yellow heads. More common along roadsides further north in Florida and in Georgia where it is a common roadside weed. It seems to be more or less sporadic in our area, or perhaps it is spreading southward. Single specimens have been collected on Marco Island, just east of Naples along the Tamiami Trail, just south of Ft. Lauderdale, and recently Mr. Jack Grant of Miami has collected one plant in Coconut Grove. E.U.S. west to Texas and Mo., north to Mass. and Michigan. [Plate XIX, Fig. B.]

48. GAILLARDIA Foug.

Named for Gaillard de Charentonneau, a French botanist of the 18th century.

1. *G. pulchella* Foug., in Mem. Acad. Sc. Paris 5: 1786-1788, var. *picta* Gray, in Syn. Fla. No. Am. I: 352. 1884. BLANKET FLOWER.

Lat. *pulchellus,* beautiful, *pictas,* painted.

Escaped annuals of several different forms; sprawling or erect plants with rather weak branches; stems pubescent; leaves alternate, thickish, entire or serrate, lower leaves often pinnatifid with margins coarsely serrate or dentate, the lobes apiculate; some plants with all entire leaves, others with serrate leaves only; leaves

pubescent with soft white hairs, sessile or short-petioled, rounded and partially clasping; upper leaves linear, lanceolate or oblong.

Heads radiate, up to 5 cm. in di., at ends of long peduncles; involucre flat, bracts spreading or reflexed, thick, acuminate, in 2 or 3 series, pubescent with rather long, loose, white hairs; rays showy, up to 2½ cm. long, red or orange-red or red-purple, mostly with a yellow tip, or rays all yellow, some forms with flat ray flowers, others with rays that are almost tubular and deeply 3-5 parted; disk flowers deep purple-red, the lobes prolonged into upright long acuminate tips which are purple hairy; heads chaffy, the chaff of fine hair-like bristles; pappus of several long-awned or pointed scales.

The variety of this species is the common cultivated annual Gaillardia of this area. The plants often escape into roadsides, fields, waste places, etc., and add a touch of brilliant color to the landscape. [Plate XIX, Fig. J.]

49. Polypteris Nutt.

Gk. *poly,* many, *pteris,* wing, referring to the pappus of some species.

1. *P. integrifolia* Nutt., Gen. Am. 2: 139. 1818.
Lat. *integris,* whole, *folium,* leaf, referring to the simple undivided leaf.

Rather tall plants branching above; stems woody near the base, lined, pubescent; leaves opposite or alternate, up to 6 or 7 cm. long, lanceolate, pubescent with short hairs and rough to the touch, margins ciliate, entire, short-petioled.

Inflorescence corymbose, heads terminal on these branches; heads discoid, about 2 to 2½ cm. in di.; bracts in 2 to 3 series, outer ones green, small, reflexed, inner ones longer and mostly white and petaloid, rounded, reflexed at maturity; flowers large, up to 1 cm. long, numerous, white or pinkish, easily separated, lobes of the corolla cut rather deeply and spreading; pappus of several, long, awn-like, pubescent scales.

Polypteris can be recognized easily by the large tubular flowers and white petaloid bracts. Found in dry pinelands with acid soil and sometimes in the Miami pinelands in alkaline soil. Fla. and Ga. [Plate XIX, Fig. F.]

50. Palafoxia Lag.

Named for a Spanish general Jose Palafox, 1780-1847, defender of Saragossa against Napoleon's armies.

1. *P. Feayi* A. Gray, in Proc. Am. Acad. Sci. 12: 59. 1877.

Usually tall, shrubby plants branched above; stems woody, minutely hairy; leaves alternate, elliptic to oblong, entire, up to 8 cm. long but usually smaller, becoming smaller toward the top of the plant, short-petioled, dark green, scabrous.

Heads corymbose at end of long woody branches; heads discoid, up to 2½-3 cm. in di.; flowers arranged rather loosely; bracts not appressed, spreading, few, not margined nor petaloid, thin, narrow, obtuse, red-tipped; flowers white to pinkish, lobes of corolla erect, slightly incurved; pappus of rather short broad scales.

Characteristic plants of the acid sandy scrub lands of Broward County, Marco Island, above Naples, and in the sandy pinelands of northern Dade County. The long, often solitary, woody stem, leafless below, with only a few woody branches above, projecting out above the scrub vegetation, and the few heads with white or pinkish tubular flowers terminating these branches, characterize this species. [Plate XIX, Fig. G.]

51. Flaveria Juss.

Lat. *flavus,* yellow, from the dyeing properties of some species.

Low, herbaceous plants, usually much branched near the base, glabrous or occasionally pubescent; leaves opposite, linear, lanceolate, or elliptic, sessile or with a winged petiole, entire or sometimes serrate, often connate. Heads stalked, clustered, in a close corymb, or sessile and one-flowered and clustered in the axils of leaf-like involucres, discoid or radiate with only one ray flower; involucre of few bracts; receptacle naked or setose; flowers yellow; pappus absent.

The Flaverias are common plants and can be easily recognized by the numerous, small, few-flowered, yellow heads clustered in groups, mostly discoid but some heads may have a solitary ray flower; the leaves are usually long and narrow.

1. Leaves long linear, less than 1 cm. wide, only midrib evident ..... 1. *F. linearis*

1. Leaves lanceolate to elliptic, mostly 1 cm. or more in width, almost always 3-veined.
   2. Heads peduncled, more than 1-flowered, not clustered in axils of leafy involucres.
      3. Heads more than 8-flowered ..... 2. *F. floridana*
      3. Heads less than 8-flowered ..... 3. *F. latifolia*
   2. Heads sessile, 1-flowered, clustered in axils of leafy involucres ..... 4. *F. trinerva*

1. *F. linearis* Lag., Gen. et. Sp. Nov. 33. 1816. YELLOW TOP.
   Lat. *linearis*, pertaining to the linear shaped leaves.

Low plants usually much branched at the lower nodes, glabrous or rarely pubescent; stems often purplish, striate; leaves long linear, up to 10 cm. long, less than 1 cm. wide, sessile, somewhat thickish, only midrib evident, entire or with a few obscure teeth on margin.

Inflorescence a close flat-topped corymb; heads radiate with one ray flower, or discoid; disk flowers about 6; involucre with 1 or 2 scale-like bracts at the base and 3 to 5 boat-shaped inner bracts which are keeled, yellow, dry; ray flowers pistillate, yellow, with a broad ligule.

The most common *Flaveria* in our area; found along roadsides, waste places; glades, low pinelands, wet prairies, etc., mostly in low places but sometimes in dry pinelands. Confined to southern Florida and the Keys. Bahamas, Cuba, Mexico, Yucatan. [Plate XIX, Fig. E.]

2. *F. floridana* J. R. Johnson, in Proc. Amer. Acad. 39: 291. 1903. YELLOW TOP.

Low plants, much branched and bushy, glabrous or sometimes pubescent; stems striate, often purplish; leaves fleshy, entire or the older and larger leaves irregularly denticulate, definitely 3-veined, sessile, narrowed to a winged petiole, connate, lanceolate to elliptic or sometimes linear, up to 8 cm. long, not over 2 cm. wide.

Heads at ends of branches, clustered; flowers as in *F. linearis;* ligule present or absent; bracts usually 5 in number, 4 mm. long, few scale-like ones at base of involucre; about 8 to 10 flowers per head.

Resembling *F. linearis* but differing mainly in the width of the leaves, number of prominent veins, and the number of flowers per

head. Found in low places in the everglades and often in sandy places on Miami Beach. Ranges up the east coast to Brevard County, the west coast to Sanibel Island. [Plate XIX, Fig. C.]

3. *F. latifolia* (J. R. Johnson) Rydb., No. Am. Fl. 34: 145. 1915.
YELLOW TOP.

Lat. *latus,* wide or broad, *folium,* leaf. *F. linearis* var. *latifolia* J. R. Johnson.

Resembling *F. floridana* but differing mainly in the number of flowers per head, *F. latifolia* having more than 8 flowers and sometimes as many as 15 flowers per head; leaves broader, often coarsely serrate, but not denticulate. In low places such as wet prairies, roadsides, etc. Found in southern Florida, north to Palm Beach County.

4. *F. trinerva* (Spreng) C. Mohr., In U. S. Dept. Agr. Con. Nat. Herb. 6: 810. 1901.

Lat. *tri,* three, *nervus,* a nerve.

Low plants branched more or less dichotomously; stems glabrous, tinged with purple; leaves sessile or narrowed to a winged petiole, glabrous, somewhat fleshy, base clasping, up to 6 cm. long, margin coarsely toothed, prominently 3-veined, lanceolate to elliptic.

Heads sessile, clustered in almost every branch, in axils of leaves which act as involucres of a second order; receptacle, which is common to all the sessile heads, is chaffy, the chaff hair-like; each head 1-flowered, with 2 chaff-like colorless subulate bracts surrounding each flower and occasionally 1 or 2 thin narrow accessory bracts; many pistillate flowers in this compound head and they have short tiny ligules which are yellow; perfect flowers not as numerous, tubular, pale yellow; pistillate heads mostly marginal but often throughout the compound head.

More or less weedy plants recognized by the manner of branching and the many, clustered heads in the axils of leaves. Found in sandy soil on Miami Beach, along railroad tracks, etc.; common on the campus of the University of Miami, and along roadsides on Key Largo and in Key West. S.E.U.S. west to Arizona. Cuba, Mexico, Yucatan, British Honduras, Hawaii. South America. [Plate XIX, Fig. D.]

52. Pectis L.

Lat. *pektis*, comb, referring to the nature of the pappus.

1. Heads short-peduncled, solitary; oil glands on the lower surface of the leaves arranged in 2 lines ..... 1. *P. leptocephala*
1. Heads sessile, clustered; oil glands on the lower surface of the leaves scattered, not in lines ..... 2. *P. prostrata*

1. *P. leptocephala* (Cass.) Urban, Symb. Ant. 5: 280. 1907.
Gk. *leptos*, small, *kephale*, head.

Strongly aromatic, prostrate plants, much branched and spreading out on the ground forming mats; stems terete, purple, hairy; leaves opposite, sessile, linear, up to 3 cm. long and 2 mm. wide, usually with 3 or 4 pairs of hairs on the margins of the leaves near the base, and 2 rows of oil glands on the lower surface of the leaves.

Heads short-peduncled, solitary, not clustered; bracts 5, in 1 series; heads radiate with 5 ray flowers, ligules small, yellow; pappus of the ray flowers with 2 bristle-like scales, the pappus of the disk flowers with 5 bristle-like scales; pappus scales broad at the base and narrowing to an awn.

A common weed along roadsides and sidewalks, in cultivated areas, pinelands, waste places, fields, beaches, etc.; growing flat on the ground, with numerous small leaves and small yellow heads; giving off a fragrant, refreshing, lemon-like odor when crushed. Southern Florida and the Keys. Bahamas, Cuba, Haiti, Dominican Republic, Puerto Rico, Jamaica, Lesser Antilles. [Plate XIX, Fig. I.]

2. *P. prostrata* Cav., Icon. et Descr. Pl. 4: 12. 1797.
Lat. *pro*, forward, *stratus*, to spread out.

Prostrate, aromatic plants, much branched near the base and forming mats; stems purple, hairy, hairs more or less in lines; leaves opposite, sessile, up to 3 cm. long and 4 to 6 mm. wide, linear to spatulate, mostly with 8 pairs of cilia near the base of the leaf, glands on lower surface of the leaves scattered, not in lines.

Heads clustered at end of branches, sessile; bracts 5, boat-shaped or keeled, in 1 series, margined or winged; heads radiate, up to 1 cm. high; ray flowers 5, ligule narrow and not showy; pappus of several minute scales which are difficult to see.

A weedy plant somewhat resembling *P. leptocephala* but with wider leaves, sessile heads, and scattered oil glands. Not common; collected along roadsides north of Miami Beach, and recently

appearing as a weed on the University of Miami Campus, Florida to Arizona. Cuba, Bahamas, Antigua, and throughout Central America. [Plate XIX, Fig. H.]

Plate XX. A. *Emilia coccinea;* 1. lower leaf, 2. upper stem leaf. B. *Mesadenia Elliottii;* 1. basal leaf, 2. stem leaf. C. *Mesadenia lanceolata;* 1. basal leaf, 2. stem leaf.

53. Emilia Cass.

Origin of name not known.

1. *E. coccinea* (Sims) Sweet, Hort. Brit. ed. 3: 382. 1839. TASSEL FLOWER.

Lat. *coccineus,* scarlet.

Weak, erect herbs; stems sparingly hairy; leaves alternate, sessile, mostly on lower part of plant, becoming smaller and fewer on the upper part of the plant, auricled at the base and clasping, scattered white hairs on the blades, acute, coarsely toothed or sinuate-dentate, but never cut very deeply, lower leaves spatulate or oblanceolate, often with the blade reduced to a winged petiole, upper leaves lanceolate and sessile.

Heads on long naked peduncles, corymbs little branching; involucre of 1 series of bracts, about 10 to 12 mm. high; heads discoid; flowers reddish or scarlet, sometimes fading to a lilac or rose-purple color; pappus silky capillary.

A common weed growing about a foot high, with weak stems, long peduncles, and small but prominent, reddish tubular flowers. Found in lawns, roadsides, fields, cultivated places, etc. In southern Florida and the Keys. Naturalized from the Old World tropics. Throughout the West Indies, Central America and South America. Hawaii, East Indies. In Malay the young leaves are eaten either raw or cooked. [Plate XX, Fig. A.]

E. sonchifolia (L.) DC., Prodr. 6: 302. 1837. This species is given for the Miami area, and there are herbarium specimens collected by Small from Palm Beach County in 1904 and 1919. It has lilac or purplish flowers, heads 10 mm. high or less; plants slenderer, most leaves smaller and fewer in number and lyrate pinnatifid.

54. Mesadenia Raf.

Gk. *mesos,* middle, Lat. *dentis,* tooth, referring to the central projection of the receptacle of some of the species.

1. Leaves mainly lanceolate ..... 1. *M. lanceolata*
1. Leaves mainly ovate ..... 2. *M. Elliottii*

1. *M. lanceolata* (Nutt.) Raf. New Fl. Am. 4: 79. 1832. INDIAN PLANTAIN.

Lat. *lanceola,* lance. *Cacalia lanceolata* Nutt.

Medium tall, semi-succulent herbs, with thick rootstalks, entirely glabrous throughout; stems green, upper part of stem grooved; leaves alternate, entire or more or less undulate or rarely minutely serrate, glaucous, fleshy, mostly 3 to 5 veined, rather distant; lower leaves lanceolate, petioled or blade narrowing into a winged petiole, up to 3 dm. long, becoming smaller toward the top of the plant, the upper leaves linear or narrowly lanceolate, sessile, leaves much reduced in the inflorescence.

Inflorescence a wide spreading corymb; heads discoid, usually more or less drooping but sometimes erect, peduncled; heads about 1 to 1½ cm. long, cylindric, about 4-flowered; bracts in 1 series, pale yellow-green or sometimes greenish-white, subulate, united, appressed, sometimes tipped with red-purple or entirely red-purple, keeled; flowers with a long tube and a short campanulate throat, the lobes often curled back, white or sometimes reddish in color; pappus of capillary bristles.

A conspicuous plant with long, light green stems, long, narrow, whitish leaves, and white or pinkish heads projecting above the surrounding vegetation and nodding in the breeze; sometimes growing in large colonies and the white heads can be spotted from some distance away. Found mostly in moist places such as low pinelands, glades, wet prairies, and edges of ditches. S.E.U.S. west to La. and north to No. Car. [Plate XX, Fig. C.]

2. *M. Elliottii* Harper, in Torreya 5: 184. 1905. INDIAN PLANTAIN.
Named for Stephen Elliott, 1771-1830, a botanist of South Carolina. *Cacalia ovata* Chapm.

Plants resembling *M. lanceolata* but the leaves are ovate or oval in outline, entire or slightly undulate. Probably not a good species but should rate at least a varietal rank. Plants can be found that grade into *M. lanceolata.* In low places with the same habitat as *M. lanceolata.* S.E.U.S. to La. and Ga. [Plate XX, Fig. B.]

55. ERECHTITES Raf.

Gk. *erechtites,* name for some species of groundsel.

1. *E. hieracifolia* (L.) Raf., in DC., Prodr. 6: 294. 1837. FIRE WEED.
Hieracium, generic name for hawk weed, Lat. *folium,* leaf.

Tall, weedy annuals resembling Sonchus; stems hairy, green, occasionally purple, with many grooves, watery and succulent; leaves alternate, pubescent, lanceolate to linear or spatulate in outline, deeply cut, toothed, incised, or pinnatifid, or merely serrate, sessile with auricled clasping bases, or petioled and not clasping; the lower leaves usually petioled and not divided, the upper leaves mostly deeply cut, sessile and clasping.

Heads discoid, corymbed, clustered; involucre swollen at the base, about 2 cm. high; bracts in 1 series with a few smaller narrow bracts at the base of the involucre; flowers whitish or tinted with yellow or pink; pappus white capillary.

A weedy plant with long, dark green or reddish, pinnatifid leaves and numerous, non-showy heads. Found along roadsides, in fields, waste places, cultivated areas, etc. Universal from Florida to Canada and west to the Rocky Mountains. Throughout the West Indies, Central America and South America. Hawaii. In Asia the young tops and the tender foliage are eaten raw or cooked. In Europe used as a potherb and the leaves are used in salads. [Plate XXI, Fig. B.]

56. Senecio L.

Lat. *senex*, an old man, referring to the hoary character of some species, or to the white pappus.

1. S. *glabellus* Poir., Encyc. 7: 102. BUTTERWEED, RAGWORT.
Lat. *glabellus*, hairless, smooth. S. *lobatus* Pers.

Succulent, glabrous, annual herbs with grooved stems; main leaves basal forming a rosette; leaves alternate, sessile with auricled, clasping bases, pinnately parted sometimes to the midrib, lobes cuneate to sub-orbicular, the divisions dentate with a pointed apiculate tip, the terminal lobe usually the largest.

Inflorescence corymbose; heads radiate, conspicuous with many bright yellow-orange flowers; heads up to 1½ cm. in di., peduncled; involucre of 1 series of bracts, up to 5 mm. high; ligules showy, up to 5 mm. long, 3-toothed; pappus capillary; flowers fragrant.

Very showy plants with light green, much dissected leaves and brilliant yellow-orange heads; often growing in large colonies. Found mostly in damp or moist soil of the everglades, damp woods,

etc. Common in low places north and west of Hialeah and along some ditches and canals in Collier County. E.U.S. north to Ill. and Mo., west to Texas. [Plate XXI, Fig. A.]

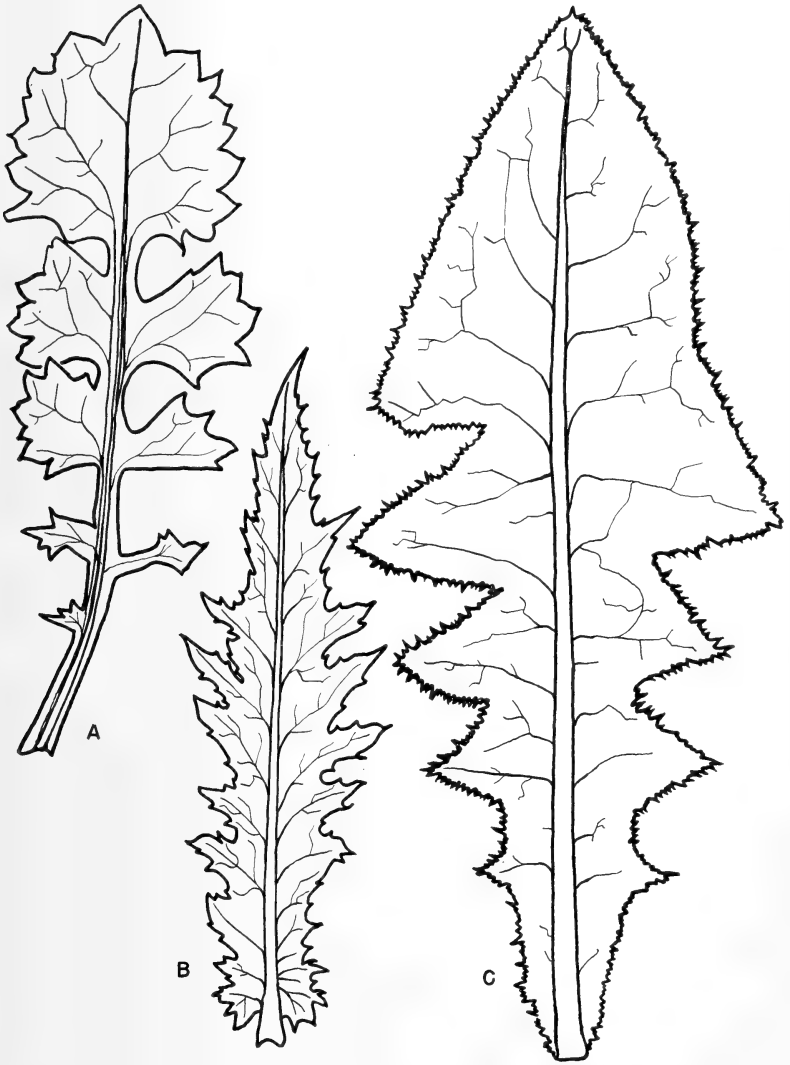

Plate XXI. A. *Senecio glabellus.* B. *Erechtites hieracifolia.* C. *Lactuca intybacea.*

57. Cirsium Hill

Gk. *kirsos,* a swollen vein, for which the thistle was supposed to be a remedy.

1. *C. horridulum* Michx. Fl. Bor. Am. 2: 90. 1803. Var. *Elliottii* (T. & G.) Fern. PURPLE THISTLE.

Lat. *horridus,* prickly. *G. spinosissium* (Walt.) Scop.

Usually tall, herbaceous, prickly plants often with purple stems and leaves, white woolly pubescent throughout; leaves alternate, main leaves basal forming a rosette, leaves up to 3 dm. long, lobed or deeply cut with many spreading spines on the margins; stem leaves sessile, clasping and not as deeply cut.

Heads terminal, often clustered, large and conspicuous, discoid, up to 6 and 8 cm. in di.; involucre consisting of a whorl of large leaf-like and weak spine-tipped bracts at the base and then many spineless bracts in several series; bracts silky pubescent; flowers numerous, large, very long, throat and styles purple or sometimes cream-colored; pappus capillary, silky white.

A common, conspicuous somewhat attractive plant with a large rosette of prickly leaves, large heads of purple or cream-colored flowers, and a whorl of spine-tipped bracts below the involucre. The color of the flowers varies from deep rose-purple, almost red, and typical lavender and light shades, to pale yellow, cream and white. Mostly in moist soil of the everglades, wet prairies, glades, etc., but also along roadsides, beaches, and in dry pinelands. The species ranges from Florida to Maine and west to Texas. Also Bahamas. [Plate XXII, Fig. D.]

The only thistle in south Florida is the variety of this species. Further north the flowers are all pale yellow or cream, but in our area the purple-flowered variety is the most prevalent. There are forms, however, that have cream or yellow-cream colored flowers. Two additional species, *C. Smallii* Britton and *C. vittatum* Small, have been made based mainly on the color of the flowers, the length of the flowers, and the leaves which may or may not be pinnatifid to any great extent. These two forms grow mostly in the dry pinelands and sandy places and are not nearly as tall as the typical *C. horridulum;* they may have either purple or cream-colored flowers. It seems to me that *C. Smallii* and *C. vittatum* are merely ecological variations or at most only varieties of *C.*

horridulum; therefore all the thistles found in our area I have called *C. horridulum* var. *Elliottii* regardless of the color of the flowers or the degree of pinnatification of the leaves.

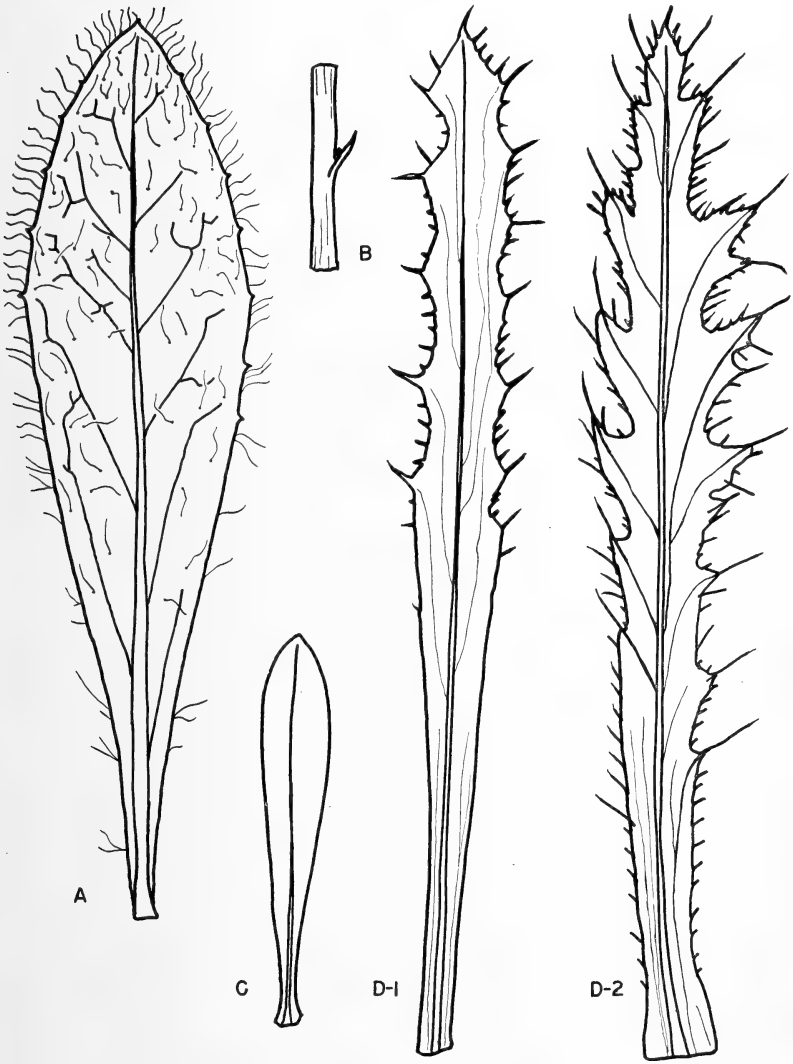

Plate XXII. A. *Hieracium megacephalum.* B. *Lygodesma aphylla.* C. *Chaptalia dentata.* D-1 and D-2. *Cirsium horridulum* var. *Elliottii.*

Murrill in research notes on *Circium Smallii* and *C. horridulum*, in the Quarterly Journal of the Florida Academy of Sciences, 12: 65-66, 1949, reports on a study he made of these two species in natural habitats and of seedlings which he grew in the greenhouse. He presents data to show that these two species are quite distinct. The main differences may be summarized as follows:

C. horridulum var. *Elliottii*	*C. Smallii*
1. Larger and taller plant.	1. Slenderer and shorter plant.
2. Usually in low ground — swamps, wet meadows, rich pastures, etc.	2. Usually in dry pinelands & sand dunes.
3. Takes two years to flower.	3. Takes one year to flower.
4. Leaves more deeply cut, the margin crinkled; the prickles larger and longer; midrib purple.	4. Leaves less deeply cut, the margins not crinkled; the teeth shallow, close and small; midrib green.
5. Seedlings more hairy.	5. Seedlings less hairy.

If the plants do differ this much, then certainly they may be considered as two distinct species.

Cirsium lanceolatum (L.) Hill, the bull thistle, naturalized of Europe, with conspicuously winged stems, prickly leaves, and lilac or violet colored flowers, seems to be moving southward. It was collected in northern Broward County and southern Palm Beach County. In time it might be found in the Miami area.

58. Chaptalia Vent.

Named for J. A. C. Chaptal, 1756-1831, French Chemist and statesman.

1. *C. dentata* (L.) Cass., Dict. Sc. Nat. 26: 104. 1823. PINELAND DAISY.

Lat. *dentis*, referring to the toothed leaves.

Low herbaceous plants with leaves basal forming a rosette; leaves spatulate or oblanceolate, narrowed gradually to a winged petiole, glabrous and bright green above or in young leaves tomentose above, white woolly tomentose below, margins serrate or dentate, the teeth small and far apart, only the midrib evident.

Scape from center of the rosette, white woolly; heads solitary, inconspicuously radiate; involucre up to 2 cm. high, swollen at the base, the bracts in several series, tomentose, reflexed after maturity, inner bracts longer; ray flowers not showy, only the upper part of the small purple or red-tipped ligules appearing around the margin

of the head, projecting out beyond the conspicuous pappus; disk flowers greenish, small, with a long slender tube enlarged at the tip, the lobes not reflexed, 2-lipped, 2 lobes cut deeper than the other 3 lobes; pappus capillary.

Small, inconspicuous plants with a basal rosette, leaves green above and white-woolly beneath, the heads small, terminating a scape, the flowers insignificant. Found in dry pinelands especially around sink holes, and often growing in grassy places in lawns and boulevards; not common. Southern Florida and the Keys. Bahamas, Cuba, Haiti, Dominican Republic, Jamaica, Puerto Rico.

C. tomentosa Vent. grows further north in Florida. It differs from *C. dentata* by having broadly winged petioles, prominent showy ligules, and disk flowers that are conspicuously 2-lipped. [Plate XXII, Fig. C.]

Subfamily Cichorieae

59. Lygodesmia D. Don.

Gk. *lygos,* a pliant twig, *desmos,* ligament, from the rush-like stems.

1. *L. aphylla* (Nut.) DC., Prod. 7:198. 1837. rose-rush.
Gk. *a.* without, *phyllon,* leaf.

Herbaceous plants with milky sap; stems rush-like, solitary or with a few branches near the base, glabrous, green, little branching above; basal leaves few, linear, elongated, or absent; stem leaves absent, or if present mere scales only a few mm. long.

Heads 5 to 10 flowered with all ligulate flowers, large and showy, up to 5 cm. in di.; involucre cylindric, 2 cm. high, bracts in a few series, the outer only 1 or 2 mm. long, the inner much longer, linear; ligules 2 cm. long, rose-colored or purplish or rarely white, apex toothed; pappus capillary; achene not beaked.

Unusual plants with long, green, naked, rush-like stems and large, conspicuous heads. Found in sandy, acid soil of the scrub lands north of Ft. Lauderdale in Broward County, and above Naples on the west coast in Collier County. Florida and Georgia.

60. Hieracium L.

Gk. *hierakos,* a hawk, the Greek name. Hawks were supposed to use the plant to strengthen their eyesight.

1. *H. megacephalon* Nash. Bull. Torr. Bot. Club, 22: 152. 1895. HAWK WEED.

Gk. *megas,* large, *kephale,* head.

Low, herbaceous plants with milky juice; main leaves basal forming a rosette; basal leaves short-petioled or the blade narrowed to a winged petiole, obovate to spatulate, entire or with a few short teeth, with prominent, long, white, loose, silky hairs which may be as much as 1 cm. long; stem leaves few in number, distant, greatly reduced, sessile, clasping, mostly linear, pubescent.

Scape hairy, corymbosely branched above, the heads terminal on these branches; involucre cylindric, narrow, bracts in 2 or 3 series, pubescent with gland-tipped hairs; flowers all ligulate, bright yellow; pappus a dirty tawny color; achene ribbed, dark brown, beakless.

Plants with large, hairy, basal leaves in a rosette, and a central scape bearing several bright yellow heads. Found in dry pinelands. Not too common. Florida and Georgia. [Plate XXII, Fig. A.]

61. Lactuca L.

Lat. *lactis,* milk, referring to the milky juice.

1. Margins of the leaves without spines; Flowers not yellow ..... 1. *L. graminifolia*
1. Margins of the leaves with soft spines; flowers pale yellow ..... 2. *L. intybacea*

1. *L. graminifolia* Michx., Fl. Bot. Am. 2: 85. 1803. WILD LETTUCE.

Lat. *graminis,* grass, *folium,* leaf.

Weedy, herbaceous plants with milky juice; leaves at base of plant and on the lower part of the stem greatly elongated, from 15 to 40 cm. long, but seldom over 1 or 2 cm. wide, entire or mostly pinnatifid with only a few distant divisions which are more or less deltoid in shape, apiculate, and mostly pointed downward, or if not pinnatifid the leaves entire or serrate with a few widely scattered minute teeth; the upper leaves and those of the inflorescence usually entire and much reduced, mostly under 6 cm. long and conspicuously clasping with auricled bases and acute to acuminate tips; all leaves pale green, glabrous or often with hirsute hairs on the midrib below or occasionally on the blades.

Heads up to 2 cm. long, erect, on peduncles that have scale-like

bracts; involucre swollen at the base or cylindric, bracts in several series, green, usually with a purple tip, or becoming entirely red-purple with age, inner bracts much longer, some bracts with scarious margins; flowers all ligulate, the ligules pale purple to reddish-blue, 1 cm. long, 5-pointed; achene flat, body about 5 mm. long, dark brown, the beak almost as long as the body; pappus capillary.

Before flowering, the lower leaves are clustered in large rosettes, the leaves long and narrow, almost grass-like; the inflorescence widely branching and producing numerous heads which are usually bluish. Found in cultivated places and roadsides. S.E.U.S. west to Texas and north to North Carolina. [Plate XXIII, Fig. A.]

2. *L. intybacea* Jacq., Icon. Plant. Rar. 1: 16. 1786. WILD LETTUCE.
Lat. *intybus,* the Latin name of chicory. *Brachyrhampus intybaceus* (Jacq.) DC.

Annual, weedy herbs with milky juice, glabrous throughout, the stems and leaves thickish and somewhat succulent; main leaves basal forming a rosette; stems much branched above the base; leaves alternate, entire or pinnatifid, pale green, sessile, clasping, the upper leaves sagittate and auricled clasping; margins spiny, but the spines soft, not sharp, spines about ½ mm. long, with dark red tips.

Heads borne on short peduncles all along the many branches, peduncles mostly less than 2 cm. long, with scale-like bracts; heads erect, averaging 1 cm. long and 1½ cm. wide, mostly 1 or sometimes 2 or 3 at a node; involucre swollen at the base, bracts scarious-margined; flowers all ligulate, the ligules yellow or pale lemon color or rarely white; pappus white silky; achene ribbed, the ribs with minute spines, beak very short or absent.

Easily recognized by the large, yellow-green leaves more or less forming a basal rosette, and the much branching inflorescence with pale yellow heads. Found along roadsides, in cultivated grounds, waste places, etc. Common in cleared areas and roadsides on the Keys; apparently spreading northward into the Miami area. Naturalized from Tropic America. Cuba to Trinidad, Jamaica, Mexico, Venezuela. [Plate XXI, Fig. C.]

L. floridana (L.) Gaertn. with glabrous, sessile leaves which may be simple and coarsely dentate or lyrate pinnatifid, long acuminate,

and with purple-blue ligulate flowers, has been collected along the roadsides in damp soil above Ft. Lauderdale near Oakland Park. This species does not seem to have become established in our area as yet; but, like *Circium lanceolatum*, may possibly reach the Miami area in time.

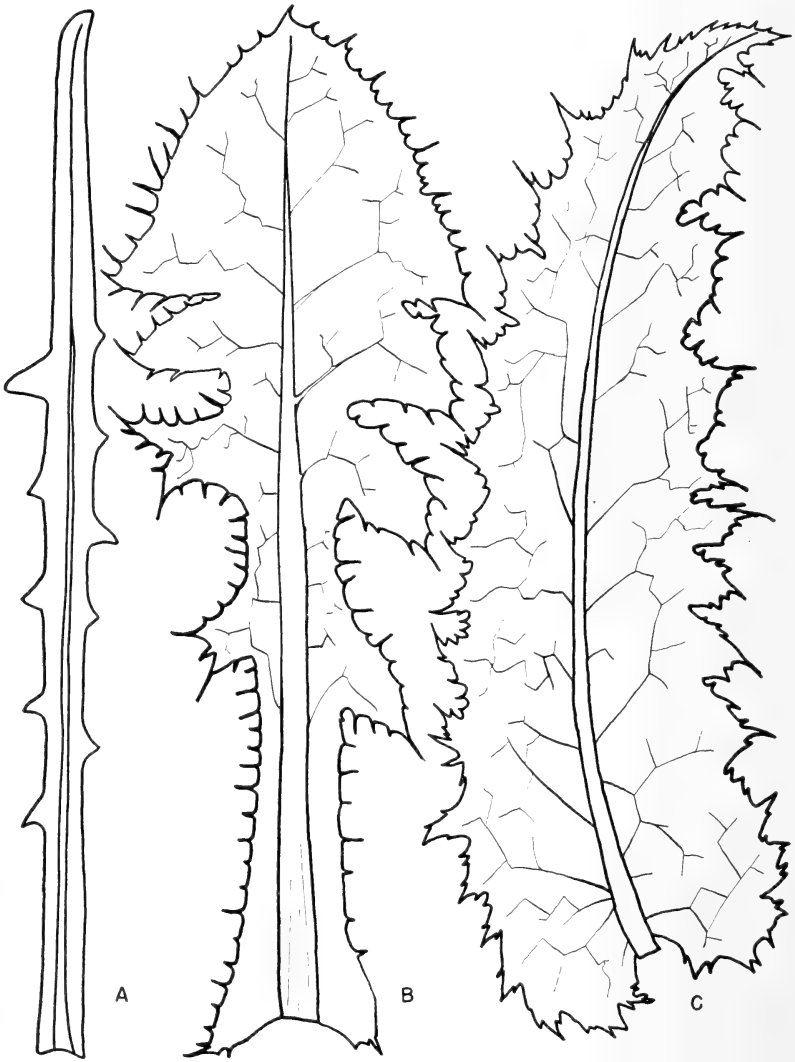

Plate XXIII. A. *Lactuca graminifolia.* B. *Sonchus oleraceus.* C. *Sonchus asper.*

62. Sonchus L.

Gk. *sonchus,* the sow thistle.

1. Auricles of the leaves pointed at the base; achene ribbed and transversely wrinkled ..... 1. *S. oleraceus*
1. Auricles of the leaves rounded at the base; achene merely ribbed, not transversely wrinkled ..... 2. *S. asper*

1. *S. oleraceus* L., Sp. Pl. 794. 1753. sow thistle.
Lat. *oleraceus,* resembling herbs.

Weedy plants with milky juice and somewhat succulent stems and leaves; stems thick, striate, often purple; leaves alternate, glabrous, lower ones petioled, upper ones sessile and clasping with an auricled base which is pointed or acute, the stem leaves few and distant; leaves pinnatifid, deeply cut or the upper ones not divided, the terminal lobe usually the largest and triangular in shape, margins soft spiny.

Heads up to 2 cm. in di., on long naked peduncles, in loose corymbs; involucre ovoid, swollen at the base, bracts in several series; flowers all ligulate, the ligules pale yellow; pappus of capillary, silky bristles; achene flattened, beakless, ribbed and transversely wrinkled. [Plate XXIII, Fig. B.]

2. *S. asper* (L.) All., Herb. Brit. 1:47. 1769. sow thistle.
Lat. *asper,* rough or thorny.

Resembling *S. oleraceus* but differing in the following respects: leaf blades with rigid teeth or spines; leaves less divided, more often entire; auricles rounded at the base; achene merely ribbed, without cross lines. [Plate XXIII, Fig. C.]

Both species of sow thistles are native to Europe and have been naturalized throughout United States, Canada, West Indies, Mexico, Central America, and South America. They are weedy plants found growing along roadsides, in cultivated areas and waste places. They are easily identified by the pinnatifid leaves which have soft or rigid spines on the margins of the blades, auricled leaf bases which clasp the stem, and by the pale yellow, ligulate heads. *S. asper* is not quite as common as *S. oleraceus.* Both species are used as potherbs and the leaves can be used in salads.

CULTIVATED COMPOSITAE

Sixty one species of composites are herein recorded as plants suitable for growing in the gardens of south Florida. The majority of these are annuals. Some of the more common annuals are floss flower *(Ageratum conyzoides* and *A. Houstonianum),* calendula *(Calendula officinalis),* China aster *(Callistephus chinensis),* cosmos *(Cosmos bipinnatus* and *C. sulphureus),* gaillardia *(Gaillardia pulchella),* sunflowers *(Helianthus* spp.), marigolds *(Tagetes* spp.), and zinnia *(Zinnia elegans).* Among the perennials are aster or Michaelmas daisy *(Aster* spp.), chrysanthemum *(Chrysanthemum* spp.), gerbera *(Gerbera Jamesoni),* climbing senecio or Mexican flame vine *(Senecio confusus),* Mexican sunflower *(Tithonia difersifolia),* and wedelia *(Wedelia trilobata).*

Several native species such as *Conoclinum, Spilanthes, Rudbeckia hirta, Aster carolinianus,* and *Helianthus debilis,* are occasionally planted in the garden; and there are many more native species that would make good ornamentals. Among the latter are *Vernonia Blodgettii, Liatris* spp., *Helenium vernale, Carphephorus corymbosus, Berlandiera, Actinospermum.*

Most of the cultivated species have been seen and collected by the author; several species that have not been found growing in this area have been included because others (Cervassee, 1941; Dahlberg, 1936; Dorn, 1928; Watkins, 1937) have recommended them as suitable plants for south Florida.

The ray flowers are usually in one row. But in many cultivated composites the ray flowers have been increased in number so that they frequently occupy many rows and often obscure the disk flowers *(Calendula, Callistephus, Dahlia, Rudbeckia laciniata, Tagetes, Zinnia,* etc.). These are the so-called "double flowers" which, in reality, are not true double flowers since the composite head is already "double", being composed of many flowers borne on a common receptacle.

The key to the cultivated composites and the brief descriptions of the species that follow the key are included in this report mainly to help one to identify the cultivated species. No information is given on how to grow the plants. This information if desired may be found in the books and publications listed in the references.

Key To The Cultivated Composites Of South Florida

1. Heads composed of all ligulate flowers; plants with milky juice.
   2. Flowers blue ..... 16. *Cichorium intybacea*
   2. Flowers yellow ..... 38. *Lactuca sativa*
1. Heads composed of tubular flowers only or tubular flowers and ligulate flowers.
   2. Heads discoid, the flowers all tubular.
      3. Leaves opposite.
         4. Pappus capillary; plants perennial ..... 17. *Conoclinum coelestinum*
         4. Pappus of minute scales; plants annual.
            5. Involucre 3 mm. high; leaves 2-4 cm. long ..... 1. *Ageratum conyzoides*
            5. Involucre 5 mm. high; leaves 4-7 cm. long ..... 2. *Ageratum Houstonianum*
      3. Leaves alternate.
         4. Involucre bracts united and in 1 series, with or without several small bracts at the base of the involucre.
            5. Herbs; leaves glabrous or sparingly white-hairy; without small bracts at base of involucre ..... 24. *Emilia flammea*
            5. Sub-shrubs; leaves with conspicuous reddish-purple hairs; with several small bracts at base of involucre ..... 29. *Gynura aurantiaca*
         4. Involucre bracts in several series, not united.
            5. Involucre bracts not enlarged nor colored and without thickened green or brown bases.
               6. Woody plants; leaves aromatic, silvery gray tomentose; heads yellow ..... 45. *Santolina chamaecyparissus*
               6. Herbaceous plants; leaves not aromatic.
                  7. Involucre bracts spreading ..... 26. *Gaillardia pulchella*
                  7. Involucre bracts erect, not spreading.
                     8. Involucre bracts ciliate ..... 10. *Centaurea cynaus*
                     8. Involucre bracts entire ..... 11. *Centaurea moschata*
            5. Involucre bracts enlarged and colored and with thickened green or brown bases.
               6. Achene glabrous; pappus bristles not plumose at base; plants minutely pubescent ..... 35. *Helichrysum bracteatum*
               6. Achene pubescent; pappus bristles plumose at base; plants glabrous.
                  7. Leaves elliptic or ovate; peduncles without scarious bracts ..... 36. *Helipterum Manglesii*
                  7. Leaves linear, spatulate-linear or the upper lanceolate; peduncles naked ..... 37. *Helipterum roseum*
   2. Heads radiate (Often the disk flowers are obscured by the numerous rows of ray flowers).
      3. Leaves opposite.

4. Leaves simple, entire or merely toothed, not compound, lobed, nor divided.
   5. Leaves sessile.
      6. Leaves clasping ..... 61. *Zinnia elegans*
      6. Leaves not clasping ..... 33. *Helianthus floridanus*
   5. Leaves petioled.
      6. Erect Plants.
         7. Leaves white silky tomentose ..... 31. *Helianthus argophyllus*
         7. Leaves not white silky tomentose.
            8. Petiole winged ..... 34. *Helianthus tuberosus*
            8. Petiole not winged ..... 30. *Helianthus annuus*
      6. Prostrate plants.
         7. Leaves pubescent; receptacle not elongated at maturity.
            8. Heads subtended by a pair of leaf-like bracts; heads 1.5 cm. in diameter ..... 46. *Sanvitalia procumbens*
            8. Heads not subtended by a pair of leaf-like bracts; heads over 1.5 cm. in diameter ..... 32. *Helianthus debilis*
         7. Leaves glabrous; receptacle elongated at maturity ..... 49. *Spilanthes repens*
4. Leaves lobed or divided, at least on the lower part of the plant.
   5. Leaves merely lobed with 3-5 divisions ..... 59. *Wedelia trilobata*
   5. Leaves pinnately divided.
      6. Involucre bracts in 1 series, united to the top; leaves with oil glands, aromatic.
         7. Heads up to 2.5 cm. in diameter, with 5 yellow rays ..... 53. *Tagetes signata*
         7. Heads usually more than 2.5 cm. in diameter, with more than 5 rays.
            8. Rays yellow orange, marked with red or brown; plants up to 4.5 dm. tall; heads about 3 cm. in diameter ..... 52. *Tagetes patula*
            8. Rays yellow or orange and not marked with red or brown; plants up to 9 or 10 dm. tall; heads 5 to 10 cm. in diameter ..... 51. *Tagetes erecta*
      6. Involucre bracts in more than 1 series, not united; leaves without oil glands.
         7. Leaves twice pinnately parted, at least near the base of the plant.
            8. Rays of a uniform color.
               9. Divisions of the leaves filiform to linear; rays white, pink, or crimson .. 20. *Cosmos bipinnatus*
               9. Divisions of the leaves lanceolate; rays yellow or orange ..... 21. *Cosmos sulphureus*

8. Rays yellow with a crimson-brown base ..... 19. *Coreopsis tinctoria*
7. Leaves once divided.
8. Rays yellow; plants annual without tuberous roots.
9. Ligules with brownish-purple base; divisions of the leaf ovate, oblong, or linear ..... 18. *Coreopsis Drummondii*
9. Rays yellow throughout; leaves 1 to 3 parted, the divisions filiform or linear.
10. The divisions of the leaf filiform ..... 39. *Leptosyne Douglasii*
10. The divisions of the leaf linear ..... 40. *Leptosyne Stilmanii*
8. Rays red, purple, pink, yellow, or white; perennials with tuberous roots; leaves 3 to 7 parted, the divisions ovate and toothed .. 22. *Dahlia variabilis*

3. Leaves alternate, at least above, or basal.
4. Most leaves basal forming a tufted plant.
5. Leaves pinnately lobed, white woolly beneath ..... 28. *Gerbera Jamesoni*
5. Leaves not divided, spatulate or obovate, glabrous ..... 6. *Bellis perennis*
4. Stems leafy.
5. Plants with white silky or woolly tomentose.
6. Rays white above and violet beneath ..... 3. *Arctotis grandis*
6. Rays yellow ..... 31. *Helianthus argophyllus*
5. Plants not white silky or woolly.
6. Leaves simple, entire or toothed but not divided, lobed, nor incised.
7. Climbing plants.
8. Rays orange-yellow or red; leaves petioled, serrate ..... 48. *Senecio confusus*
8. Rays pale pink or rose-purple; stem leaves sessile, clasping, entire ..... 4. *Aster carolinianus*
7. Plants not climbing.
8. Leaves and bracts spinulose .... 50. *Stokesia laevis*
8. Leaves and bracts not spinulose.
9. Receptacle elongated, cone-shaped.
10. Leaves entire, 2.5 to 5 cm. long ..... 42. *Rudbeckia bicolor*
10. Leaves serrate, 5 to 15 cm. long ..... 43. *Rudbeckia hirta*
9. Receptacle not elongated.
10. Pappus capillary.
11. Rays yellow .. 60. *Xanthisma texanum*
11. Rays not yellow.

12. Heads 5 to 10 cm. in diameter; outer bracts reflexed or spreading, leaf-like; plants annual ..... 9. *Callistephus chinensis*
12. Heads mostly under 5 cm. in diameter; outer bracts not leafy nor reflexed; plants perennial ..... 5. *Aster* spp.

10. Pappus not capillary, of scales or absent.
11. Prostrate plants ..... 32. *Helianthus debilis*
11. Erect plants.
12. Leaves glabrous.
13. Bracts in 1 series; leaves linear-oblong; rays usually orange or yellow but often white, blue, red, or salmon .. 23. *Dimorphotheca aurantiaca*
13. Bracts in several series; leaves spatulate or oblanceolate; rays white ..... 14. *Chrysanthemum maximum*
12. Leaves pubescent.
13. Leaves sessile.
14. Leaves clasping; bracts in 1 or 2 series ..... 8. *Calendula officinalis*
14. Leaves not clasping; bracts in several series.
15. Leaves revolute; disk flowers without elongated lobes ..... 33. *Helianthus floridanus*
15. Leaves not revolute; disk flowers with elongated lobes ..... 26. *Gaillardia pulchella*
13. Leaves petioled.
14. Petiole not winged ..... 30. *Helianthus annuus*
14. Petiole winged.
15. Plants only 3 to 5 dm. tall; leaves white tomentose,

upper leaves glabrous ..... 58. *Venidium decurrens*

15. Plants 15 to 60 dm. tall; all leaves hirsute .. 34. *Helianthus tuberosus*

6. Leaves divided, lobed, pinnatifid, bipinnatifid, or deeply incised.
   7. Leaves merely 3 to 5-lobed, tall, more or less woody plants.
      8. Rays yellow ..... 55. *Tithonia diversifolia*
      8. Rays orange ..... 56. *Tithonia rotundifolia*
   7. Leaves divided, pinnatifid, bipinnatifid, or deeply incised.
      8. Leaves white silvery, with or without an orange yellow border ..... 47. *Senecio cineraria*
      8. Leaves not white silvery.
         9. Leaves pubescent.
            10. Lobes of the disk flowers conspicuously awned; rays red or yellow.
               11. Plants annual 26. *Gaillardia pulchella*
               11. Plants perennial ..... 25. *Gaillardia aristida*
            10. Lobes of the disk flowers not awned.
               11. Plants strongly scented or aromatic.
                  12. Leaves lobed or deeply incised; leaves with gray pubescence; plants perennial ..... 15. *Chrysanthemum morifolium*
                  12. Leaves bipinnatifid, pubescence not grayish; annuals ..... 57. *Ursinia pulchra*
               11. Plants not aromatic; leaves lyrate-pinnatifid, tomentose; annuals.
                  12. Rays yellow ..... 58. *Venidium decurrens*
                  12. Rays blue ..... 41. *Machaeranthera tanacetifolia*
         9. Leaves glabrous, at least in age.
            10. Heads with three colors ..... 12. *Chrysanthemum carinatum*
            10. Heads not in three colors.
               11. Involucre of 1 series of bracts united for over half their length ..... 27. *Gamolepis tagetes*

11. Involucre in more than 1 series; bracts not united.
    12. Plants aromatic.
        13. Leaves bipinnate, the divisions linear; heads 5 cm. in diameter ..... 57. *Ursinia pulchra*
        13. Leaves pinnatifid, the divisions filiform; heads 1 to 2 cm. in diameter ..... 54. *Thymophylla tenuiloba*
    12. Plants not aromatic.
        13. Receptacle elongated at maturity; rays lemon yellow ..... 44. *Rudbeckia laciniata*
        13. Receptacle not elongated at maturity.
            14. Leaves small, pinnately divided, the divisions narrow; bracts in few series, subequal; rays blue, rose, or white .. 7. *Brachycome iberidifolia*
            14. Leaves larger, deeply pinnatifid, the divisions narrow; bracts in several series; rays yellow or yellow-white ..... 13. *Chrysanthemum coronarium*

Descriptions of the Cultivated Compositae of South Florida

1. *Ageratum conyzoides* L. Annual from Tropical America. FLOSS FLOWER.

   Leaves opposite, ovate to deltoid, crenate, 2-4 cm. long. Heads clustered, discoid, mostly blue but some varieties with white or pink flowers; involucre 3 mm. high.

2. *Ageratum Houstonianum* Mill. Annual from Mexico. FLOSS FLOWER.

   Resembling the preceding species but the involucre is 5 mm. high and the leaves are larger, 4-7 cm. long. Both species have dwarf and tall varieties.

3. *Arctotis grandis* Thunb. *(A. stoechadifolia* Berg.). Annual from South Africa. BLUE-EYED AFRICAN DAISY.

   Upright herbs, somewhat bushy, with alternate leaves, and white woolly throughout. Heads radiate, the rays white above, violet beneath, disk flowers with a bluish cast; heads on long peduncles. The flowers close at night.

4. *Aster carolinianus* Walt. Native of Florida. CLIMBING ASTER.

   Woody plants with long arching branches; leaves alternate, entire, clasping. Heads 3-5 cm. in di., ligules pale pink or rose-purple; involucre bracts spreading. Woody vines suitable for use as garden climbers.

5. *Aster* spp. HARDY ASTER, STARWORT, MICHAELMAS DAISY.

   There are several species of Asters which can be grown in Florida. They are all perennials and have the typical aster-like head. Rays white, blue, red, or purple. *Aster laevis* L. (native to N.E. North America), and its cultivated varieties, is most often seen in cultivation; lower leaves winged-petioled, upper leaves clasping; leaves thick and glabrous; often glaucous; heads radiate with rich blue ligules.

6. *Bellis perennis* L. Perennial (but annual in Florida) from Western Europe. ENGLISH DAISY.

   Leaves spatulate, mostly basal or near the base of the plant; heads rather large on long peduncles, the rays mostly white but also rose or red.

7. *Brachycome iberidifolia* Benth. Annual from Australia. SWAN RIVER DAISY.

   Low plants with alternate, pinnately divided leaves, the divisions narrow, acute. Heads 2-3 cm. in di., the rays blue, rose or white.

8. *Calendula officinalis* L. Annual from southern Europe. CALENDULA, POT MARIGOLD.

   Leaves alternate, thick, sticky, aromatic, entire or minutely toothed, clasping, pubescent, oblong or lanceolate. Heads large and showy, the rays orange or yellow in many rows; bracts of the involucre in one or two series. In Europe the yellow heads are dried and used for flavoring soups and stews, and the leaves are used in salads.

9. *Callistephus chinensis* Nees. Annual native of China. ANNUAL OR CHINA ASTER.

Leaves alternate, pubescent, broadly ovate, deeply toothed or incised. Heads large and showy with a wide range of size, shape, and color — violet, purple, blue, rose, white; outer bracts of the involucre large, green and reflexed or spreading, ciliate. Heads mostly "double".

10. *Centaurea cyanus* L. Annual from southeastern Europe. CORN FLOWER, BLUE BOTTLE, BACHELOR'S BUTTON.

Leaves linear to lanceolate, woolly when young, entire or the lower toothed and occasionally pinnatifid. Flowers all tubular but the marginal ones enlarged and resembling ray flowers; flowers blue, white, pink, red, or purple; bracts of the involucre in several series, conspicuously ciliate or fringed.

11. *Centaurea moschata* L. Annual from the Orient. SWEET SULTAN.

Leaves toothed or pinnatifid, the lobes dentate. Flowers all tubular, white, yellow, or purple; heads long peduncled. Differing in one respect from *C. cyanus* by having the involucre bracts entire.

12. *Chrysanthemum carinatum* L. Annual from Morocco. TRICOLOR CHRYSANTHEMUM.

Leaves alternate, thickish, grayish, pubescent when young, twice pinnatifid, the lobes linear. Heads long peduncled, in three colors, the rays white, red, brownish purple, or pink, a ring of yellow or purple color at the base of the rays and purple disk flowers.

13. *Chrysanthemum coronarium* L. Annual from the Mediterranean. ANNUAL CHRYSANTHEMUM.

Glabrous, branched herbs with deeply pinnatifid leaves, the divisions narrow and toothed or incised, leaves not thick. Rays yellow or white, small and daisy-like. In China and Japan the young tender shoots are cooked and eaten.

14. *Chrysanthemum maximum* Ram. Perennial from the Pyrennes. SHASTA DAISY.

Lower leaves often quite long, spatulate or oblanceolate,

obtuse, serrate, glabrous. Heads on long peduncles; rays white; disk flowers yellow.

15. *Chrysanthemum morifolium* Ram. Perennial, Asiatic. GARDEN CHRYSANTHEMUM.

Leaves ovate in outline, short-petioled, toothed and variously lobed or deeply incised, gray-white pubescent, with a strong odor. Heads radiate, varying in size, shape, color, and form. In Japan the leaves and flower heads are used for salads.

16. *Cichorium intybus* L. Native of southeastern Europe but well established in the United States. CHICORY, BLUE SAILORS.

Perennial herbs with milky juice; basal leaves clustered, pinnatifid or sharply incised, with scattered hairs, often ciliate; stem leaves reduced, lanceolate, clasping, sessile, minutely hairy and ciliate. Heads numerous, sessile or short-stalked, clustered, axillary or terminal; flowers all ligulate, blue or lavender. Sometimes grown in Miami gardens for its leaves which are cooked like spinach or used in a salad. The long thick taproot is the source of chicory used in making a special kind of coffee.

17. *Conoclinum coelestinum* (L.) DC. Native perennial. MIST FLOWER.

Plants resembling *Ageratum* but differing in being perennial and the pappus capillary. Heads small and clustered, discoid, flowers blue.

18. *Coreopsis Drummondii* Torr. & Gray. Annual native to Texas. GOLDEN WAVE.

Leaves opposite, pinnately divided, the divisions ovate, oblong, the upper ones linear. Heads radiate, the rays yellow with a brownish-purple base; disk flowers dark purple; involucre bracts in two series of 8 each, the inner ones united at their base; outer bracts as long as the disk flowers.

19. *Coreopsis tinctoria* Nutt. Annual native to Central United States from Texas to Canada. CALLIOPSIS.

Leaves opposite, lower ones twice pinnately parted, the lobes linear-lanceolate or linear; the upper leaves sessile

or with a winged petiole, once pinnate. Rays yellow with crimson-brown bases, or the entire ligule may be brown; disk flowers brownish-purple or dark red; outer bracts much shorter than the disk flowers.

20. *Cosmos bipinnatus* Cav. Annual from Mexico. EARLY COSMOS.
Leaves opposite, bipinnatifid, the divisions filiform to linear or lanceolate, glabrous. Heads peduncled, the rays white, pink, or crimson.

21. *Cosmos sulphureus* Cav. Annual from Mexico. KLONDYKE OR YELLOW COSMOS.
Leaves opposite, bipinnatifid, the divisions lanceolate, glabrous. Heads long peduncled, radiate, the rays yellow or golden yellow (or orange in var. Golden Flare).

22. *Dahlia pinnata* Cav. *(Dahlia variabilis* Desf.). Perennial from Mexico. GARDEN DAHLIA.
Leaves opposite, at least the lower ones, pinnate with 3-7 ovate, pointed, dentate leaflets, the rachis often winged; roots tuberous. Heads radiate, nodding, the rays red, purple, pink, yellow, or white; heads varying greatly in size, shape and color, mostly "double". Treated as an annual here if grown from the tubers, or as a biennial if grown from seed. The tubers contain inulin which is used as a substitute for starch.

23. *Dimorphotheca aurantiaca* DC. Annual from Africa. ORANGE AFRICAN DAISY, CAPE MARIGOLD.
Dwarf spreading plants; leaves alternate, linear-oblong, tapering to the base, entire or mostly coarsely toothed, glabrous, sticky. Heads radiate with long bright yellow or orange rays, some varieties with white, blue, red or salmon colored rays; bracts in one series.

24. *Emilia flammea* Cass. Annual from the New World tropics, resembling *Emilia coccinea* introduced from the Old World tropics. FLORA'S PAINT BRUSH, TASSEL FLOWER.
Basal leaves with a narrow winged petiole, upper leaves with a broad winged petiole or sessile to a clasping base; heads on long peduncles, discoid in a loose corymb, the tubular flowers a bright scarlet (golden yellow in one form); involucre bracts in one series and united.

25. *Gaillardia aristida* Pursh. Perennial native to the American western plains. BLANKET FLOWER, GAILLARDIA.

Leaves entire or pinnately lobed, sessile, pubescent, lanceolate or oblong. Heads large, the rays flat or somewhat tubular, yellow or red; disk flowers with conspicuous awns on the lobes of the corollas.

26. *Gaillardia pulchella* Foug. var. *picta* Gray. ANNUAL GAILLARDIA, BLANKET FLOWER.

The species native to Arkansas, Texas, and Arizona, the cultivated forms classified under the variety.

Plants resembling the perennial Gaillardia and it is difficult to tell the two apart; rays yellow at the tip and rose or red purple at the base, or some forms with all yellow flowers: Ray flowers often enlarged and almost tubular, in one or several rows; sometimes the heads composed of all tubular flowers.

27. *Gamolepis tagetes* DC. Annual from South Africa. GAMOLEPIS

Low, wiry, much branched plants; leaves alternate, glabrous, pinnately parted, the divisions linear and toothed or pinnatifid. Heads radiate, rays yellow or orange; involucre of one row of bracts united over half their length.

28. *Gerbera Jamesoni* Bolus. Perennial from South Africa. GERBERA DAISY, TRANSVAAL DAISY, BARBERTON DAISY.

Leaves basal, petioled, blade entire to pinnately lobed or variously parted, hairy, mostly woolly tomentose beneath, up to 15-20 cm. long, Heads very large and showy, at ends of long hollow peduncles; involucre of several series of overlapping, erect, hairy, pointed bracts; rays numerous, tending to be in more than 1 row, orange, red, pink, white, cream, salmon, gold, rose or violet, some tend to have rays a different color beneath; disk flowers same color as the ray flowers or perhaps a little lighter, the tube 2-lipped (as in our native *Chaptalia),* the tube split unequally, the lobes curling back; pappus capillary. A very beautiful herbaceous garden perennial in flower most of the year. Cut flowers will last 1-2 weeks.

29. *Gynura aurantiaca* DC. Perennial from Java. VELVET PLANT.

Low, much branched, sub-shrubs with woody stems;

leaves alternate, ovate, toothed, petiole winged, upper leaves sessile and clasping; pubescence of soft, red or red-purple hairs. Heads discoid, flowers orange or red; involucre of 1 series of united bracts and a small set of bracts near the base. Grown for the velvet foliage.

30. *Helianthus annuus* L. Annual native to the western plains and west to the Pacific Coast. COMMON SUNFLOWER.

Plants rough hairy, leaves opposite below and alternate above, long-petioled, lanceolate to ovate, serrate. Heads often extremely large (over 1 foot in di.); rays yellow, disk flowers mostly brown-purple. Often cultivated for the seeds which contain an oil that is used in varnishes, soups, oleomargine, salad dressings, and cooking oils.

31. *Helianthus argophyllus* T. & G. Annual native to Texas. SILVER-LEAF SUNFLOWER.

Tall much branched plants with alternate, ovate, entire, petioled leaves that are densely white silky tomentose and silvery in appearance. Heads about 10 cm. in di., rays yellow, disk flowers magenta-red.

32. *Helianthus debilis* Nutt. Annual native to Florida. BEACH SUNFLOWER.

Prostrate plants, the flowering stems erect; common on the beaches and often cultivated in the gardens. Leaves hispid, ovate, toothed, petioled. Rays yellow, the disk flowers brown-purple. Can be used as a ground cover.

Helianthus debilis var. *cucumerifolius* (T. & G.) Gray, the cucumber-leaf sunflower, native to eastern Texas and La., is sometimes cultivated but more common in the northern states where it as well as the species are treated as annuals; both have escaped from gardens to the fields as far north as Maine. The variety is an erect plant up to 5 or 6 feet tall and the stems are conspicuously mottled.

33. *Helianthus floridanus* Gray. Perennial native to the southeastern United States. FLORIDA SUNFLOWER.

Erect plants; leaves alternate or opposite, lanceolate, sessile, scabrous, revolute. Heads 4-5, in a loose panicle; rays yellow; disk flowers with red-brown lobes.

34. *Helianthus tuberosus* L. Perennial native to United States and Canada. JERUSALEM ARTICHOKE.

Leaves opposite below, alternate above, petiole winged, hirsute, ovate to oblong, toothed. Heads large, rays yellow and the disk flowers yellow. The roots contain inulin, source of fructose sugar. The tubers resemble potatoes and they are cooked or eaten raw as a substitute for the Irish potato or pickled and made into a relish.

35. *Helichrysum bracteatum* Andr. Annual from Australia. STRAWFLOWER, EVERLASTING.

Leaves alternate, oblong-lanceolate, entire. Heads discoid, the flowers yellow; outer bracts of the involucre short, the inner bracts enlarged and elongated, papery, petaloid, showy, colored yellow, white, red, or orange, with bases green and thickened.

36. *Helipterum Manglesii* Muell. *(Rhodanthe Manglesii* Lindl.). Annual from Australia. EVERLASTING.

Plants glabrous, leaves alternate, entire, elliptic to ovate, clasping. Heads on bracteate stalks, discoid, flowers yellow; involucre bracts in several series, the outer ones scarious or membraneous and silvery, the inner ones colored and petal-like, pink, white, or red, resembling ray flowers.

37. *Helipterum roseum* Benth. *(Acroclinum roseum* Hook.). Annual from Australia. EVERLASTING.

Leaves numerous, alternate, linear, spatulate-linear, or the upper lanceolate. Heads on naked peduncles; outer involucre bracts with brown scarious tips, the inner bracts pink or white, petal-like.

38. *Lactuca sativa* L. Native of southern Europe. CULTIVATED LETTUCE.

Leaves alternate, glabrous, more or less orbicular, often curled, stem leaves clasping, serrate; basal leaves forming a dense rosette resembling cabbage. Heads of all ligulate flowers, the flowers yellow. Grown for the leaves which are a source of vitamins and certain minerals, otherwise of little food value; used mainly in salads. Some of the varieties in cultivation are the following: var. *capitata,* head lettuce;

var. *crispa,* curled lettuce; var. *longifolia,* romaine or cos lettuce; var. *asparagina,* celtuce or asparagus lettuce.

39. *Leptosyne Douglasii* DC. Annual native to the southwest United States. LEPTOSYNE.

Leaves alternate or the lower opposite, usually somewhat fleshy, 1 to 3 parted, the divisions filiform, most of the leaves near the base of the plant. Heads long-stalked, the rays bright yellow.

40. *Leptosyne Stillmanii* Gray. Annual from southern California. LEPTOSYNE.

Differing from the above species in that the lobes of the leaves are linear instead of filiform.

41. *Machaeranthera tanacetifolia* Nees. Native to western states. TAHOKA DAISY.

Leaves alternate, pubescent, narrow, 1 to 3 times compound, fern-like, lobes linear, up to 7 or 8 cm. long; young plants forming a rosette. Heads radiate, up to 5 cm. in di., the ligules bright blue, the disk flowers yellow.

42. *Rudbeckia bicolor* Nutt. var. *superba.* Annual, the species native to southeastern United States. BLACK-EYED SUSAN.

Leaves alternate, lanceolate to elliptic, hispid, sessile, 2½ to 5 cm. long, or longer, entire or nearly so. Rays 2½ to 3 cm. long, yellow with purplish-brown at base; disk flowers brown or dark-purple; receptacle cone shaped, elevated above the ray flowers.

43. *Rudbeckia hirta* L. Perennial native to eastern United States. BLACK-EYED SUSAN.

Leaves alternate, oblong-lanceolate, serrate, 5 to 15 cm. long, rough hairy. Rays yellow, disk flowers dark purple-brown; receptacle elongated, cone-shaped.

44. *Rudbeckia laciniata* L. var. *hortensia.* Perennial, the species native to eastern United States. GOLDEN GLOW.

Tall, much branched plants, glabrous or essentially so throughout; leaves alternate, lower ones with 3 to 7 lobes, pinnately compound or deeply and often irregularly lobed, the upper ones mostly simple. Heads numerous, long-

peduncled, radiate with many rows of lemon-yellow ray flowers obscuring the disk flowers; receptacle at first globular but with age elongating and cone-shaped. Does well in everglades muck or marl.

45. *Santolina chamaecyparissus* L. Perennial from the Mediterranean Region. LAVENDER COTTON.

Much branched plants with woody stems up to 2 feet high; leaves alternate, aromatic, silvery-gray tomentose, much divided into many minute lobes. Heads discoid, yellow, up to 2 cm. in di., on long peduncles. Grown mostly for the foliage and used as a ground cover.

46. *Sanvitalia procumbens* Lam. Annual from Mexico. CREEPING ZINNIA.

Stems low, trailing, much branched; leaves opposite, ovate, up to 2½ cm. long, petioled, pubescent, entire. Heads radiate, small, 1½ cm. in di., rays yellow, disk flowers purple. Heads subtended by a pair of leaf-like bracts.

47. *Senecio cineraria* DC. Perennial from the Mediterranean region. DUSTY MILLER.

Plants white woolly throughout; leaves pinnatifid, the divisions oblong. Heads radiate, small, 5-15 mm. high, in small clusters. Herbaceous perennials up to 9 dm. tall, branching at the base; grown for the white or silvery foliage, or in one variety with orange-yellow border on the leaves.

48. *Senecio confusus* Britton. Perennial from Mexico. MEXICAN FLAME VINE, CLIMBING SENECIO.

Climbing woody plants; leaves alternate, thick, ovate to lanceolate, tapering gradually to an acute or acuminate tip, base truncate, margin dentate with minute dark-colored tips, petioled, glabrous or nearly so, often suffused with red. Heads radiate, 4-5 cm. in di., showy, with orange or orange-red ligules turning red as the flowers fade; bracts in 1 series, united for half their length.

Often confused with another species — *Senecio scandens* Buch. Ham., native of China. *S. scandens* has flowers that

are more orange-yellow and not fading to red; the stem and leaves are finely pubescent; and the leaves frequently have 2 divisions present at the base of the blade.

49. *Spilanthes repens* Michx. Native perennial. SPILANTHES.

Recommended for a ground cover in low and moist places. Stems reclining, spreading, leaves opposite, short-petioled, thickish, glabrous, or sometimes pubescent, 2-3 cm. long. Heads radiate, small, up to 15 mm. high; rays yellow; receptacle elongating at maturity, cone shaped.

50. *Stokesia laevis* Greene. Perennial native to Ga., La., and So. Car. STOKES ASTER.

Rather low growing plants with alternate, oblong to lanceolate, thickish, spinulose-leaves which are toothed near the base. Heads radiate, the rays purplish-blue; bracts spinulose.

51. *Tagetes erecta* L. Annual from Mexico. AFRICAN MARIGOLD.

Aromatic plants with pinnately divided leaves, the divisions oblong or lanceolate, sharply serrate, with a few large glands near the margins below the teeth. Heads 3-10 cm. in di., usually "double," rays many, ranging in color from lemon-yellow to orange; involucre bracts in one series, united.

52. *Tagetes patula* L. Annual from Mexico. FRENCH MARIGOLD.

Aromatic, dwarf and compact plants with pinnately divided leaves, the divisions lanceolate or oblong, sharply serrate, each tooth with a large gland at the base. Heads 2-4 cm. in di., usually "double", rays many, yellow and often with red or brown markings; involucre bracts in one series, united.

53. *Tagetes signata* Bartl. var. *pumila.* Annual native to Mexico. BABY MARIGOLD.

Low, aromatic plants with pinnately divided leaves, each segment with two rows of large orange colored glandular dots. Heads small, rays few, about 5, yellow; involucre bracts in one series, united.

54. *Thymophylla tenuiloba* (DC) Small. Annual native to Texas & Mexico. DAHLBERG DAISY.

Low, aromatic plants with finely cut blades, the divisions filiform or linear. Heads radiate, 1-2 cm. in di., rays yellow.

55. *Tithonia diversifolia* (Hemsl.) Gray. Perennial shrub from Mexico. MEXICAN SUNFLOWER.

Woody plants; leaves 3-5 lobed, alternate, ovate in outline, serrate, white-pubescent beneath, scabrous above. Heads large and showy, on long peduncles swollen just below the involucre; ligules bright yellow.

56. *Tithonia rotundifolia* Blake. Annual from Mexico. MEXICAN SUNFLOWER.

Tall plants often woody near the base; leaves alternate, 3-5 lobed, ovate in outline, rough pubescent, serrate, palmately veined, petiole winged, clasping; stem soft white hairy. Heads radiate, large, on long peduncles which are swollen and hollow just below the involucre; ligules orange.

57. *Ursinia pulchra* N. E. Br. Annual from Cape region of South Africa. URSINIA.

Leaves alternate, bipinnate, the divisions linear; leaves strongly scented. Heads radiate, 5 cm. in di., solitary on long peduncles; rays yellow or orange with purple-brown base; involucre bracts in 4 rows, the outer rows with a brown scarious border, the inner rows with a white scarious border.

58. *Venidium decurrens* Less. Annual from South Africa. VENIDIUM.

Leaves alternate, tomentose, lyrate pinnatifid or frequently simple, soft tomentose, toothed, prominently veined; petiole winged. Heads solitary, radiate, rays golden yellow, white, cream, etc., with a dark base; disk flowers dark; heads 2½ to 6 cm. in di.

59. *Wedelia trilobata* A. Hitch. Perennial from tropical America. WEDELIA.

Much branched, creeping herbs used for ground covers; leaves 3-5 lobed. Heads radiate, rays yellow.

60. *Xanthisma texanum* DC. Annual from Texas. STAR OF TEXAS.

Leaves alternate, sessile, glabrous, narrow, the lower

pinnatifid or toothed, the upper entire or toothed, tending to curl or twist. Heads radiate, up to 5 cm. in di.; rays and disk flowers a brilliant yellow.

61. *Zinnia elegans* Jacq. Annual from Mexico and South America. ZINNIA.

Pubescent plants; leaves ovate to lanceolate, entire, opposite, acute, sessile, definitely clasping, 3-5 veined. Heads with purple, red, yellow, white, pink, orange or lilac rays; flowers mostly "double", the disk flowers practically absent in most forms.

Glossary

Achene. A small, dry, hard, one-seeded indehiscent fruit.
Actinomorphic. Applied to a flower with radial symmetry.
Acuminate. Gradually tapering to a long point.
Acute. Sharp, short pointed.
Adnate. United.
Alternate. One leaf at a node.
Angled. Having a sharp edge or projection.
Annual. Of only one year's duration.
Apex. Tip or upper end.
Apiculate. Ending in a short pointed tip.
Appressed. Lying close to or against another organ.
Aromatic. With a spicy odor, especially when the leaves are crushed.
Auricle. An ear-shaped appendage.
Awn. A slender hair-like structure.
Axil. The angle between the leaf and stem.
Axillary. Borne in the axils of the leaves.

Basal. Referring to the base.
Beak. A narrow, elongated tip.
Bicarpellate. Two carpels.
Bipinnate. Twice pinnate or twice compound.
Blade. The flat, expanded part of a leaf.
Bract. A small, reduced leaf subtending a flower or cluster of flowers; the leaf-like scales making up the involucre.
Bristle. A stiff hair.

Campanulate. Bell shaped, broad at the base.
Canescens. Hoary, with grey hairs.
Capillary. Very fine hairs.
Carpel. A simple pistil or a member of a compound pistil.
Cell. A cavity or chamber of the ovary containing the seed or seeds.
Chaff. Small, dry scales subtending the disk flowers.
Cilia. Marginal hairs.
Clasping. Said of the base of a leaf when it partially surrounds the stem.
Compound leaf. One which is divided to the midrib into several leaflets.
Conic. Shaped like a cone.
Connate. United.
Cordate. Heart-shaped.
Corm. A short, thick, more or less globular stem without fleshy leaves.
Corolla. That part of the flower made up of the petals.
Corymb. A flat-topped or convex flower cluster.
Corymbose. In corymbs.
Creeping. Growing along or under the ground.
Crenate. Scalloped with rounded teeth.
Cuneate. Wedge shaped.
Cylindrical. Elongated and circular in cross section.

Deciduous. Falling off after maturity or at the end of a season.
Decumbent. Reclining or growing along the ground, the upper part ascending.

Decurrent. Said of leaf bases that run down the stem below the node of attachment.
Deltoid. Triangular in outline.
Dentate. Toothed, the teeth directed more or less outward.
Denticulate. With small teeth.
Dioecious. Unisexual, with stamens and pistils on different plants.
Discoid. A composite head in which all flowers are tubular.
Disk flower. Tubular flowers.
Dissected. Cut or divided deeply into numerous segments.
Divergent. Growing away from each other.
Divided. Lobed to the base.

Elliptic. Widest at the middle and tapering to both ends.
Entire. The margin even, not toothed.
Epigynous. A flower with the sepals, petals, and stamens borne on top of the ovary.
Epipetalous. Said of the stamens when borne on the corolla tube.
Erect. Standing upright.
Erose. A margin irregularly toothed, as if gnawed.

Fascicled. Densely clustered, as of several leaves at one node.
Fertile flower. One which produces seeds.
Filiform. Thread-shaped.
Fleshy. Soft, succulent, watery.
Foliacious. Leaf-like.

Glabrous. Smooth, not hairy.
Gland. A secreting surface or structure appearing as minute dots or as minute hair-like protuberances on the surface of a leaf or bract.
Glandular. Bearing glands or gland-like.
Glaucous. Covered with a fine, mealy substance, light greenish white in color.
Groove. A channel or furrow running lengthwise on the stem.

Hastate. Arrow-shaped, the basal lobes directed outward, divergent from each other.
Head. A cluster of sessile flowers borne on a very short axis.
Herb. A non-woody plant.
Herbaceous. Of the nature of an herb.
Hirsute. A type of pubescence with stiff short hairs.
Hispid. A type of pubescence with bristly stiff hairs.
Hoary. A type of pubescence with grayish-white fine hairs.

Imbricate. Overlapping, like tiles on a roof.
Incised. Cut irregularly or often coarsely.
Inferior. Said of an organ if it is situated below another one.
Inflorescence. The part of a plant that produces the flowers.
Involucre. A circle or group of leaf-like structures (bracts) subtending a cluster of flowers.
Involute. Rolled inward.

Keel. A central projecting ridge, like the keel of a boat.
Keeled. Having a keel.

Lanceolate. Lance shaped, widest below the middle and tapering more toward the upper end; several times longer than broad.
Ligulate. Strap-shaped.
Ligule. A strap-shaped organ, the ray flowers.
Linear. Many times longer than wide, the margins parallel.
Lobe. A division of an organ.
Lyrate pinnatifid. Lyre-shaped, with the terminal lobe the largest and rounded.

Midrib. The central main vein of a leaf.
Midvein. Same as midrib.
Mucronate. A small, short, abrupt tip.

Nerve. A vein of a leaf.
Node. That part of the stem that produces a leaf.

Oblanceolate. Widest above the middle and tapering toward the base.
Oblong. Somewhat longer than broad and with the margins parallel.
Obovate. An ovate leaf, widest above the middle and tapering toward the base.
Obtuse. Rounded on the end.
Oil glands. Small oil secreting glands on the surface of the leaves.
Opposite. Two leaves at a node, opposite each other.

Oval. An elliptic leaf that is only a little longer than broad.
Ovate. Egg-shaped, broadest below the middle and tapering more toward the apex, but only a few times longer than broad.

Panicle. A type of compound inflorescence, a branching raceme.
Pappus. The modified calyx of the composite flower.
Peduncle. The stalk of a flower cluster.
Perennial. Lasting for more than one year.
Perfect. A flower having both stamens and pistils.
Persistent. Organs remaining attached after maturity.
Petaloid. Petal-like.
Petiole. The stalk of a leaf.
Pinna. One of the divisions of a compound leaf, a leaflet.
Pinnate. A compound leaf in which the pinnae are borne along a common stalk.
Pinnately. Divided in a pinnate manner.
Pinnatifid. Parted or lobed with shallow incisions; not cut clear to the midrib.
Pistillate. A flower with pistils and no stamens.
Plumose. A capillary pappus with fine hairs on each side of the bristles, like a feather.
Prostrate. Lying or growing flat on the ground.
Pubescence. Referring to the hairs.
Pubescent. With hairs.
Punctate. Dotted with surface or internal pitted glands.

Raceme. A type of inflorescence in which the flowers (or heads) are stalked and borne on an elongated axis.
Radiate. A composite head in which both ray and disk flowers are present.
Ray flowers. The marginal, zygomorphic, ligulate flowers.
Receptacle. The flattened or conic end of the stalk on which the flowers are borne.
Recurved. Bent backward or downward.
Resinous. Resin-bearing.
Revolute. A leaf margin that is rolled backward or under.
Ribbed. Having prominent strong veins or ridges.
Rootstalk. An underground stem.
Rosette. A cluster of leaves growing close to or on the ground, circular in outline.

Scabrous. Rough to the touch.
Scale. A small, thin, much reduced leaf.
Scape. A single stalk arising from a rosette, not branching until the inflorescence, usually with only a few heads at the upper end.
Scarious. Thin, dry, membraneous, not green.
Serrate. A margin with saw-like teeth, the teeth usually pointed upward.
Sessile. Without a stalk, petiole, peduncle, or pedicel.
Setose. Having bristles.
Shrub. A woody perennial usually with many stems from the ground.
Simple. Not compound; of one piece.
Sinuate. With strongly wavy margins.
Spatulate. Spoon-shaped.
Spike. A type of inflorescence, the flowers sessile and borne on an elongated axis.
Spine. A sharp-pointed outgrowth.
Staminate. A flower with stamens and no pistils.
Stoloniferous. A plant having stolons, runners, etc.
Strap-shaped. Long and narrow in outline.
Striate. Marked with long lines.
Subequal. Nearly equal.
Subtend. To stand just below.
Subulate. Awl-shaped, narrowed upward to a slender point.
Succulent. Juicy or fleshy.
Sympetalous. Petals united.
Synantherous. Stamens united by their anthers.
Syncarpous. Carpels united.

Teeth. The small projections along the margins of a leaf.
Terete. Round, circular in cross section.
Tomentose. A type of pubescence in which the hairs are densely matted and wool-like.
Tripinnatifid. Three times pinnatifid.
Tubular. Tube-shaped.

Turbinate. Top-shaped.

Undulate. A wavy margin.
Unilateral. One-sided.
Unisexual. Of one sex.

Villous. A type of pubescence with long soft hairs not matted together.
Viscid. Sticky.

Webby. With a tuft of hairs.
Winged. Said of a structure having a thin membraneous border; or a structure with broad outgrowths or ridges.

Zygomorphic. Applied to a flower with bilateral or irregular symmetry.

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NEWS AND COMMENTS

With this number the Associate Editor bids farewell for a year. Recipient of a General Education Board grant he is off to Harvard and Woods Hole for a year of work in genetics and ecology.

The annual meetings are scheduled to be held in Tampa on November 30 and December 1. A schedule of the meetings is printed in Vol. 14(1) of the JOURNAL. The deadline for titles of papers to be presented is October 31.

Dr. Tom Odum is the proud father of a bouncing baby girl, while Dr. and Mrs. E. Lowe Pierce have added another cute little blonde girl to their family.

Dr. James A. Oliver has resigned his position as Assistant Professor of Biology at the University of Florida to accept the position of Curator of Reptiles at the New York Zoological Gardens.

Dr. R. Bruce Ledin is now with the University of Florida. He is presently stationed at the Sub-Tropical Experiment Station at Homestead, Florida, as an Assistant Horticulturist.

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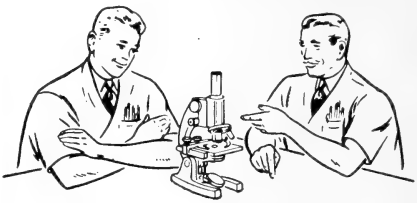

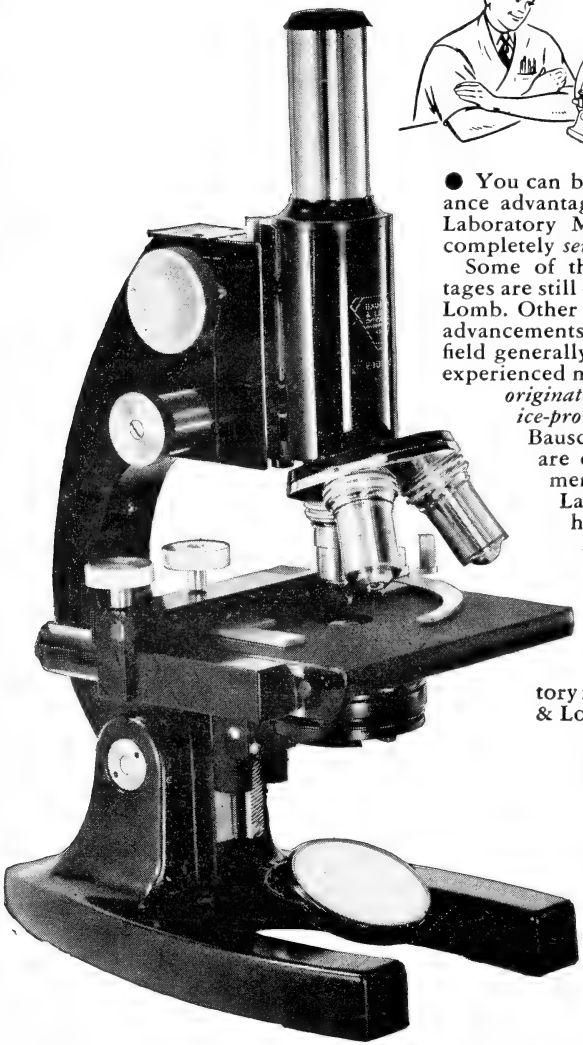

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THE QUARTERLY JOURNAL OF THE
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THE PROBLEM OF STRATIFIED RANDOM SAMPLING

JOHN P. GILL
Atlanta Division, University of Georgia

The main objective of this paper is to stress the importance of experimental work in testing statistical theory. The medical scientists experiments with dogs, mice, etc. The engineer builds his models and tests his theories. The chemist and the physicist have long learned the importance of laboratory tests. However, the applied social scientist when acting in the capacity of applied statistician *experiments* with *vital social statistics.* Evidently the rewards for doing just such a thing are still great enough for one who goes out into society and just *performs* a market survey or a public opinion survey or a Literary Digest Poll as his *experimental* model. Things go along very well until circumstances provide a *check* as was the situation in recent presidential election years. (Phillips, 1948).

Excellent sources of practical experimental models for the statistician in the social sciences are the Census publications. Here the statistician has before him a wealth of factual social data with answers to check his techniques and his theories. He performs his experiments with harm to no one. He has before him factual data. He designs his experiment; he randomizes his selections; he computes his average and dispersion measures; he makes his estimates; and he *checks* his results with the *answers;* for his statistical universes are before him in published form.

In the elementary consideration of stratified sampling one deals with the concept of picking from each stratum selected a fixed proportion of elements at random and from this sample inferences are drawn concerning the population. For example, to pick a 10% stratified sample from L strata containing, respectively, N_1, N_2, ,,,N_L items, one could choose at random 10% of the items from each stratum.

Examine the above situation very carefully. This common rule of selecting randomly the same proportion of elements from each

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stratum may not be the best procedure to follow. It is not expected that all the strata will be equally homogeneous. To illustrate this point, suppose one of the strata, say A, is ideally homogeneous, while some other, say B, is quite heterogeneous. A single element chosen from A will be sufficient to draw inferences concerning A. On the other hand, a considerable sample size from B would be necessary to draw inferences concerning stratum B. Therefore, if both A and B are sampled in proportion to their size, A would be oversampled and B would possibly be *undersampled.* This is an intuitive reasoning which can be supported quite rigorously mathematically. (Hendricks, 1948).

The Fundamental Formula in Stratified Sampling

Consider L strata with measurable data. Assume the problem is to estimate the population mean $\bar{X}$. The following assumptions are made:

1. The total number of elements, N, constituting the population is reasonably well known.

2. The standard deviations, $\sigma_1, \sigma_2, \sigma_3, , , \sigma_L$, of the respective strata consisting of $N_1, N_2,,,, N_L$ items is known. Note that $N = \sum_{i=1}^{L} N_i$.

The estimate of the population mean will be

$$\bar{X} = \sum_{i=1}^{L} N_i \bar{x}_i \Big/ N \quad , \tag{1}$$

where $\bar{x} = \sum_{i=1}^{n_i} x_i \Big/ n_i$ is the average of the n_i items chosen from the i-th stratum.

The variance, S^2, of all possible sample means $\bar{x}_i$, about the true population mean is

$$S^2 = \sum_{i=1}^{L} \frac{\sigma_i^2}{n_i} \frac{N_i - n_i}{N_i - 1} \left(\frac{N_i}{N}\right)^2 , \tag{2}$$

which is the weighted mean of the individual strata variance. (Thionet, 1946). The formula assumes sampling from a small finite population.

For the degenerate case as $N \to \infty$, (for practical purposes this mathematical assumption is used when N_i is large compared to n_i).

(3) $$S^2 = \sum_{i=1}^{L} \frac{\sigma_i^2}{n_i} \left(\frac{N_i}{N}\right)^2$$

Note: Formulas (1), (2), and (3) are generalized formulas in the sense that if one wishes to think in terms of a single random sample from the whole population, N_i becomes N and n_i becomes n, and the respective formulas reduce to $\bar{X} = \bar{x}$, the arithmetic average of the single random sample.

$$S^2 = \frac{\sigma^2}{n} \cdot \frac{N-n}{N-1} \quad , \quad \text{and for large N,}$$

$$S^2 = \frac{\sigma^2}{n} \, .$$

For a given total sample size, $\sum_{i=1}^{L} n_i = n$, the variance will obviously have different values, depending upon how the total sample was allocated to the strata. In order that the distribution of the stratified random sample means have the lowest standard error (S) the number, n_i, of elements to be chosen at random from the i-th stratum should be proportional to $\frac{N_i \sigma_i}{\sum_{i=1}^{L} N_i \sigma_i}$. Therefore, for a given total sample of size $\sum_{i=1}^{L} n_i = n$, choose the individual n_i by using

(4) $$n_i = n\left[N_i \sigma_i \Big/ \sum_{i=1}^{L} N_i \sigma_i\right] \, .$$

This is a fundamental formula in stratified random sampling (Neyman, 1938).

Immediately, the practical statistician should be cautioned as to the amount of magic which can be performed with this formula. In practice a *low* standard error might still be a considerable error since the formula above gives a *relatively* low standard error. By this is meant that out of many standard errors which might themselves be very high the above formula will assure a low standard error relative to all of these for fixed overall sample size, n.

Note: *Formula* (4) *degenerates to simple constant proportional stratified sampling designation if it is assumed that all* σ_i's *are equal.* Under these conditions

(5) $$n_i = n(N_i/N) \, . \, .$$

A simple illustration of the computations follows: Assume the number of strata is L = 5, and

N_1 =	1,000	σ_1	= 16.0	$N_1\sigma_1$ =	16,000
N_2 =	4,000	σ_2	= 13.0	$N_2\sigma_2$ =	52,000
N_3 =	6,000	σ_3	= 12.0	$N_3\sigma_3$ =	72,000
N_4 =	2,000	σ_4	= 20.0	$N_4\sigma_4$ =	40,000
N_5 =	12,000	σ_5	= 30.0	$N_5\sigma_5$ =	360,000
N	25,000			$\Sigma N_i\sigma_i$ =	540,000

It is desired to allocate a total sample size n = 2,500 in order to assure a minimum standard error. Using formula (4) determine the following:

$$n_1 = 2{,}500 \frac{16{,}000}{540{,}000} = 74$$

$$n_2 = 2{,}500 \frac{52{,}000}{540{,}000} = 241$$

$$n_3 = 2{,}500 \frac{72{,}000}{540{,}000} = 333$$

$$n_4 = 2{,}500 \frac{40{,}000}{540{,}000} = 185$$

$$n_5 = 2{,}500 \frac{360{,}000}{540{,}000} = 1{,}667$$

n	2,500

The applied problem is one of seeking to stratify the given population into strata as homogeneous as possible internally, though differing among themselves. In addition here is a means of increasing the accuracy of the results by isolating certain strata which are heterogeneous (i.e. whose σ_i^{is} are large) and by sampling these strata more heavily than the others.

Theoretically, for the individual strata σ_i^{is} as assumed above, the standard error (S) of the sample means can be computed by formula (3) on the assumption that N and N_i are sufficiently large:

$$S = \sqrt{\left(\frac{1,000}{25,000}\right)^2 \cdot \frac{(16)^2}{74} + \left(\frac{4,000}{25,000}\right)^2 \cdot \frac{(13)^2}{241} + \cdots + \left(\frac{12,000}{25,000}\right)^2 \cdot \frac{(20)^2}{1,667}}$$

$S = .48.$

Again, as the case is in so many practical problems, n_i in formula (4) depends on a knowledge of both the strata size and the strata standard deviation (i.e. on N_i and σ_i). To overcome this difficulty a preliminary investigation could be planned, and then followed up with the final investigation. The preliminary investigation would be used to determine an estimate of the individual stratum standard deviations, S_i^{is} (that is, use these to estimate the population σ_i^{is}). There must be definite knowledge about the exact size, N_i, of each stratum or an indication of a good approximation of this size. Thus

$$n_i = n\left[N_i S_i \Big/ \sum_{i=1}^{L} N_i S_i\right] \tag{6}$$

would be used in place of formula (4) to determine the optimum strata sample size. Sufficient additional elements chosen at random would be added to the samples already chosen in the preliminary investigation to make up the final strata samples based on the formula (6).

Another approach might be to search for any previous knowledge concerning the variability of the strata under investigation. It might be possible that sampling studies had been made concerning other population characteristics which are highly correlated with

the characteristics being investigated. Under such circumstances the variability of the given correlated characteristics could be used with some confidence to estimate the strata sample sizes in the present problem.

Experiment A

The states were grouped by geographic divisions as usually defined by the United States Bureau of the Census and these divisions constituted the strata for the experiment. The counties were listed as the elements of the strata with characteristic equal to number of inhabitants as of the 1940 Census. (U. S. Bureau of the Census, 1947).

In each geographic region the counties were numbered and a small random sample (approximately 5%) of counties was chosen by using a table of random sampling numbers. The number of inhabitants was recorded for these counties. The object here was to determine estimates, $S_i'^s$, of the strata standard deviations, $\sigma_i'^s$, to use in formula (6). Table 1, lists the strata sizes, N_i; the estimates, S_i, of strata standard deviations; and, finally the indicated strata sample sizes, n_i.

Assume now that it is desired to allocate a total sample size of, say, 400 counties by formula (6).

$$n_i = 400\left[N_i S_i \Big/ \sum_{i=1}^{L} N_i S_i\right] = 400 N_i S_i / 195{,}196.3$$

The values of n_i are recorded in Table 1.

TABLE 1

Experimental Results with Regional Stratification

Geographic Region	N_i	S_i (000s)	$N_i S_i$	n_i
New England	67	25.0	1,675.0	3
Middle Atlantic	150	50.6	7,590.0	16
East North Central	436	34.3	14,954.8	31
West North Central	621	16.4	10,184.4	21
South Atlantic	578	32.8	18,958.4	39
East South Central	364	15.3	5,569.2	11
West South Central	470	17.1	8,037.0	16
Mountain	277	13.5	3,739.5	8
Pacific	133	936.0	124,488.0	255*
	3,096		195,196.3	400

* Los Angeles County with 2,785,643 inhabitants was a county sampled in the Pacific Region.

The Pacific Region has caused some difficulty. Should one decide to sample all 133 counties in the Pacific Region and probably allocate the remainder of the 255 - 133 or 122 among the other eight regions? Is it not possible that such a situation would arise in a marketing survey? Random samples of counties were picked to run the estimates of σ_i. Furthermore, suppose it is assumed that the county is the smallest possible sampling unit available. It is seen, therefore, that the mathematical concepts are not the only concepts of great importance in sampling. A good knowledge of the population and how best to stratify it are at the root of the formula (4).

From the nature of the formula, therefore, it can be concluded that formula (4) or its approximate equivalent is useful for practical sampling allocations if the strata σ_i^{is}, or their approximations, satisfy certain definite prerequisites, the most important of which is that there *must* be available a reliable estimate of the σ_i^{is}. If, furthermore, some of the strata σ_i^{is} are considerably different in size from the other strata σ_i^{is}, it will be only logical to reconsider the whole project in the light of two separate studies: one for the unusual strata, the other for the strata with the more uniform standard deviations.

The experiment furnishes a good example of what might happen in practice if one blindly runs small samples to estimate standard deviations. With a poor allocation the benefits of stratification may be nullified to such a degree that the resulting sample with stratification is no better than a sample randomly drawn without stratification. Furthermore, because of the skewness of a population distribution and because of the large unit (the county) used, neither the random sampling of small size nor the stratified sampling will be of much use.

Note: In allocating sample size among the strata suppose it is decided to use *not more* than a 10% random sample from each stratum. Formula (6) would take on the following form:

$$(7) \qquad n[N_iS/\sum_{i=1}^{k} N_iS_i] \leqq 0.1N_i \quad \text{or} \quad nS/\sum_{i=1}^{k} N_iS_i \leqq 0.1 ,$$

where n is the size of the stratified random sample and S *must be*

the maximum S_i *in the particular problem.* Formula (7) may be generalized for any other percentage.

In order that formula (6) be used to allocate the total sample size, n, so that each stratum sample size n_i *be less than or at most equal to* N_i *in some cases,*

$$(8) \qquad nS \Big/ \sum_{i=1}^{L} N_i S_i \leqq 1 ,$$

where S must be the maximum S_i in the given problem.

Referring to Table 1, the maximum sized overall sample used to satisfy the conditions of formula (6) would be found as follows:

$$\frac{n\,(936.0)}{195{,}196.3} = 1, \text{ or } n = 208.$$

The allocation by regions then follows in Table 2 below.

The experiment was concluded by allocating the maximum $n = 208$ as found by formula (8), computing the estimated population of the United States from the resulting random stratified sample, and comparing the results with the true United States population.

TABLE 2

Experimental Results with Sample Size of 208

Geographic Region	N_i	n_i	$\bar{x}_i$	$N_i\ \bar{x}_i$
New England	67	2	41,996	2,813,732
Middle Atlantic	150	8	81,826	12,273,900
East North Central	436	16	37,740	16,454,640
West North Central	621	11	15,507	5,629,847
South Atlantic	578	20	39,356	22,747,768
East South Central	364	6	20,955	7,627,620
West South Central	470	8	17,379	8,169,130
Mountain	277	4	23,647	6,550,219
Pacific	133	133	73,182	9,733,206
		208		91,999,062

A considerable error is noted in the estimate inasmuch as the actual population count was 131,669,275. The error is the result of extremely small sampling from regions like the Middle Atlantic.

Either the preliminary estimates of the σ_i^{is} used in formula (6)

were considerably in error and/or the sample sizes were extremely small to warrant estimates of county averages for the regions excepting the Pacific Region.

Experiment B

The Experiment Continued Using an Aggregative Method to Determine Strata Sample Size

The experiment was performed in another way. Strata sizes proportional to the aggregate of the characteristics for the combined strata were assumed.

Weights were assigned to the regions on the basis of prior knowledge of aggregates of the characteristic sampled. It was assumed here that the 1940 Census furnished this information.

TABLE 3

Aggregative Method of Strata Sample Size Allocation

Geographic Region	Per Cent of U. S. Population	Sample Size
New England	6.41	13
Middle Atlantic	20.91	44
East North Central	20.22	42
West North Central	10.27	21
South Atlantic	13.54	28
East South Central	8.19	17
West South Central	9.92	21
Mountain	3.15	7
Pacific	7.39	15
	100.00	208

Let w_i be the weight assigned to stratum $_i$. The experiment was conducted with a modified formula

$$n_i = n\left[w_i \Big/ \sum_{i=1}^{L} w_i\right] \cdot \tag{9}$$

In Tables 3 and 4 are the results of this experiment. The discrepancy between the estimated population of 128,078,898 and the actual census figure of 131,669,275 is 3,581,377 or 2.7%.

As might be expected, this eventually leads to a sample including greater proportions of the large strata; this is a situation that

obviously is desirable on intuitive grounds alone and provides a good illustration of a mathematical justification for a sample design that seems logical to a layman.

TABLE 4

Stratified Samples by Aggregative Apportioning

Geographic Region	N_i	n_i	$\bar{x}_i$	$N_i \bar{x}_i$
New England	67	13	249,569	16,721,123
Middle Atlantic	150	44	126,859	19,028,700
East North Central	436	42	72,939	31,801,404
West North Central	621	21	24,531	15,233,751
South Atlantic	578	28	26,670	15,415,260
East South Central	364	17	19,487	7,093,268
West South Central	470	21	23,247	10,926,090
Mountain	277	7	12,470	3,454,190
Pacific	133	15	63,264	8,414,112
	3,096	208		128,087,898

Criticism

What the gain in stratified random sampling is over random sampling without stratification one is not in a position to forecast *a priori:* it depends mainly on the way the population is stratified, that is, on the quality of the stratification. If the data consisted of symmetrical distributions, probably the formula for determining strata size based on the standard deviations of the individual strata would lead to satisfactory results. However, on examining the regional distributions, it is noted that practically J-shaped distributions of counties persist in the heavily populated sections of the Northeastern part of the United States. How important standard deviations of such distributions are one hesitates to conjecture. The preliminary estimates of the standard deviations could very well be considerably in error to be of much use in formula (4).

Sensing that the population distributions in various regions gave skewed or J-shaped regional county distributions the *aggregative method* of apportioning strata sizes was used. This gave much better results. Even though less accurate data than that of the aggregates from the previous Census might have to be used, some rough approximation would still indicate the fact that the J-shaped

and skewed strata should be sampled more heavily than other regions; that is, regions whose county distribution are practically symmetrical.

In the final analysis, it must be agreed that the county unit, although giving good results in one instance, is not the most satisfactory unit. One should rely on the theory of probability and work with great numbers. *Great numbers* does not mean great numbers of people included in the sample, or great numbers that are drawn separately. Instead of dividing the population or universe into 3,096 county units as was done, if it was possible to divide the United States into much smaller subdivisions as cities, wards, or even better into much smaller units as city blocks and, finally, into dwelling units and then pick a random sample from these smaller units, one would be in a better position to draw inferences from the sample. In practice to reduce population units (as from county to city or city blocks or dwelling units) results in the necessity of listing which usually provides a limit to the tendency of having the units as small as possible.

Experiment C

Counties in the state of Texas were classified on the basis of total bank deposits of individuals, partnerships, and corporations as of December 31, 1947. Data was secured from Board of Governors of the Federal Reserve System. (Board of Governors of the Federal Reserve System, 1948). Deposits were rounded to millions of dollars and three strata were formed.

TABLE 5

Texas Counties Classified by Total Deposits of Individual, Partnerships, and Corporations, 1947

(Deposits in millions of dollars)

Stratum No.	Deposit Size	No. of Counties	Total Deposits
1	Under 9.50	169	699
11	9.50– 82.49	78	1,732
111	82.50–785.00	7	2,274
		254	4,705

The strata standard deviations and totals were computed and are presented below:

$\sigma_1 =$ \$ 2.52 millions; $N_1 = 169$; $T_1 =$ \$ 699 millions

$\sigma_2 =$ 17.65 millions; $N_2 = 78$; $T_2 =$ 1,732 millions

$\sigma_3 =$ 253.38 millions; $N_3 = 7$; $T_3 =$ 2,274 millions

$N = 254$; $T =$ 4,705 millions

$\sum_{i=1}^{3} N_i \sigma_i =$ \$3,576.24; and for $n = 50$, formula (4) gives us

$$n_1 = 50 \frac{169 \times 2.52}{3{,}576.24} = 7$$

$$n_2 = 50 \frac{78 \times 17.65}{3{,}576.24} = 20$$

$$n_3 = 50 \frac{7 \times 253.38}{3{,}576.24} = 23$$

$$n \qquad\qquad 50$$

Again, it is observed that one stratum (stratum 111) is considerably different from the other two strata. If the size of the total sample is reduced to fit the formula, there would result practically no sample values in stratum 1 and stratum 11. For example, using formula (8),

$$\frac{n(253.38)}{3{,}576.24} = 1, \text{ or } n = 14.$$

Formula (4), using $n = 14$, gives $n_3 = 13$ of these 14 units.

The sensible procedure is to sample stratum 111 completely and apply formula (4) to the two remaining strata as follows:

$$n_3 = 7$$

$$n_1 = (50 - 7)\frac{169 \times 2.52}{1{,}802.68} = 10$$

$$n_2 = (50 - 7)\frac{78 \times 17.65}{1{,}802.68} = 33$$

$$\overline{n} \qquad \overline{50}$$

Try now the aggregative method of stratified sampling. The total, T, of the characteristic (deposits) is \$4,705 millions. Applying formula (9).

$$n_1 = 50\frac{699}{4{,}705} = 7$$

$$n_2 = 50\frac{1{,}732}{4{,}705} = 18$$

$$n_3 = 50\frac{2{,}274}{4{,}705} = 25$$

$$\overline{n} \qquad \overline{50}$$

For this particular problem there is a very close relationship between the sample allocations using the aggregative method and that of formula (4). Inasmuch as stratum 111 contains only 7 items, this group was sampled completely and the remaining 43 items were allocated to strata 1 and 11 as follows:

$$n_3 = 7$$

$$n_1 = 43 \frac{699}{2{,}431} = 12$$

$$n_2 = 43 \frac{1{,}732}{2{,}431} = 31$$

$$\overline{n} \qquad \overline{50}$$

The two techniques give practically the same sample allocation with the aggregative method so much simpler to identify and to work with.

The experiments described above indicate some of the practical problems that might arise in sampling allocation. In the absence of any reliable estimates of strata standard deviations which are used in the optimum sampling formulas (4) or (6) to determine strata sample sizes, the aggregative method of allocating sample size might be used. This is particularly useful when the population strata vary considerably in size based on the total of the elements sampled and not necessarily on the number of such elements. For example, to estimate total annual gross sales of department store sales in a given section of the country the statistical population might be stratified in such a manner that the largest stores are contained in one stratum; a second stratum might consist of a group of stores somewhat smaller in annual gross sales size, etc. In the absence of any reliable estimate of strata standard deviations which could be used in the optimum formulas (4) or (6), an approximate indication of the relative size of each stratum with respect to *total* sales would suffice to be used in the aggregative method to allocate sample size.

Experiment C indicates that for the particular distribution considered the strata standard deviations were proportional to the size of the respective strata.

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THE SELF-ENERGY OF THE ELECTRON

Robert M. Frank

Florida State University

The purpose of this paper is to present an elementary review of the problem concerning the property of electrons known as the self energy and the methods of solution thereof.

It has been recognized since about 1916 that such a quantity as the self-energy must exist. The problem arose from the fact that attempts to calculate it by conventional methods yielded infinite results. Until recently, however, the self-energy never manifested itself in any observable manner and hence could be ignored in calculations of real processes.

In 1947 Lamb and Retherford reported an energy difference between the $2^2S_{1/2} - 2^2P_{1/2}$ states of hydrogen of $\Delta W/h$ equal to approximately 1000 megacycles per second. To fit this result into a consistent theory the infinite portions of the self-energy in the two states must be balanced against each other in a relativistically invariant manner or they must be calculated in such a manner that the results for each are finite (Kroll and Lamb, 1949).

The former method has been successfully applied by Schwinger (1949) and the latter by Feynman (1949). The methods have been proven equivalent by Dyson (1949). An excellent review of the theory of the electron is given by Weisskopt (1949).

The self-energy may be thought of as that portion of the electron's mass which is electromagnetic rather than inertial in character.

To get a clearer idea, imagine a single electron alone in the universe. If an electron can radiate when another electron is present to absorb a photon, it ought to be able to radiate when alone. Presumably, until a second electron absorbs the quantum, the first electron does not "know" it is there. More strictly, it is not reasonable to suppose that a second electron supplies the energy emitted by the first electron, or that it contributes a trigger action at a distance to set the first electron off. Thus an electron must have self-energy, it must be able to radiate regardless of the presence of one or more other electrons; but, if alone, it must immediately

absorb the photon which it emits. This sounds rather cannibalistic on the part of the electron, or at least introspective but there seems no escape from the conclusion.

Let us then examine the self-energy and see what has been learned about it.

From the knowledge of the coulomb force between charges, $F = k e_1 e_2 / r^2$ one is led to the definition of the potential of a charge e as $V = e/r$. The energy of a group of charges is then written as $E = \frac{1}{2} \sum_{j \neq k} \sum_{k} e_j e_k / r_{jk}$ Here we have been careful to exclude the value j equal k. For j equal k this is obviously infinite. It is however just this value of j equal k which is the classical self-energy. This fact was first recognized when Lorentz attempted to calculate the self-force of an electron in 1916. This calculation produced a term $F = -\frac{2}{3} (V/c^2) \frac{1}{2} \int de\, de'/r$ where de, de′ are charge elements within the electron and r the distance between them. This term has the form

$$F = -\frac{2}{3} (V/c^2) \Delta m \qquad \Delta m = \frac{1}{2} \int de\, de'/r$$

and Δm can then be considered as a mass or energy. It was called the self-energy. For an electron of finite size r_0 this quantity is of order $\Delta m \simeq e^2/r_0$. If we assume this to be the entire mass then $\Delta m = mc^2$ and r_0 is 2.8 times 10^{-13} cm. If however we try to go to the limit r_0 approaching zero the self-energy becomes infinite. Classically we may merely ignore the self-energy by saying that it is included in the observed mass and thereafter omit it from all calculations.

But let us now examine the problem in the light of quantum mechanics. The quantum mechanical concept of the self-energy involves the mechanism of interaction of two electrons. This interaction is two-fold: the static or coulomb action, and the dynamic or vector potential action. The quantizing of the particles requires a quantization of the field as well. Thus a plane electromagnetic wave becomes, after quantization, a photon polarized transversely with respect to its direction of propagation. It has an

energy $h\nu$ and a momentum $k = h\nu/c$ Thus two directions of polarization are associated with the dynamic portion of the interaction. The static portion can also be represented by photons if we wish, but these are polarized longitudinally.

The interaction of two charges should be regarded as an exchange of quanta between them. One charge emits a quantum which is absorbed by the other. This is the basic mechanism of interaction in the quantum mechanical formalism. The actual mechanism by which the electron which is not accelerating can emit or absorb a quantum is of course not understood. We say that such quanta are virtual and cannot be observed by any experiment. But, as noted earlier, if an electron is to emit these quanta when another electron is present to absorb them it must be able to emit them when no other electron is present. If no second electron is present the first electron must absorb its own quantum. This is the mechanism of the action of a charge upon itself and is what gives rise to the self-energy. It would seem as if we were getting in deeper and deeper instead of climbing out of the hole as now we have not only the coulomb self-energy but the transverse self-energy as well. Indeed the non-relativistic calculation yields a result depending upon $\int dk$ over all k and this will then diverge with the upper limit of the quantum energies. One might attempt to limit the quantum energy to a value $K = mc^2$ but there is no good evidence that such a procedure would be correct.

The situation is somewhat improved if one makes the calculation using the relativistic hole theory of Dirac. By this calculation the self energy becomes

$$\Delta m = \left[\tfrac{3}{2}\pi\,(e^2/\hbar c)\,m^2/E_o\right]\left[\ln(K/m)\right]$$

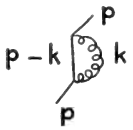
m = observed electron mass in energy units

E_o = electron energy

This is more promising since the result is much smaller for the same value of K than in the non-relativistic case. Furthermore, the result is not very sensitive to the value used for the cut-off energy K. If we desire to regard the entire mass as electromagnetic we find for K a value of 10^{100} e.v. This is greater than the energy of the entire universe. If we assume a billion universes each containing a billion suns the mass energy is only of order

10^{89} e.v. however, in order to be able to use the self-energy in problems such as the Lamb shift, it is necessary to have the cut-off energy relativistically invarient. This aim has been achieved by Feynman in his theory of quantum electrodynamics. I should like to indicate to you how the calculation can be set up and what changes Feynman has suggested in order to obtain a finite result for the self-energy.

Let us represent the process which gives rise to the self-energy schematically by the following diagram.



By momentum we shall mean a four-dimensional quantity whose space parts are the real momentum and whose time part is the energy. The electron proceeds through time with a real momentum **p** until it emits the quantum. The quantum momentum we will call **k** and the quantum energy k. The electron proceeds with momentum **p-k** until the quantum is absorbed.

It can be shown that it is correct to represensent the propagation of the electron which has momentum **p-k** by $\frac{p + m - k}{(p-k)^2 - m^2}$ and the propagation of the quantum by $1/k^2$. Further, we must represent the emission or absorption of a quantum by a matrix γ_μ where μ represents the polarization of the quantum. The symbol **A** will mean $\sum_{\mu=1}^{4} A_\mu \gamma_\mu$. And the matrices γ_μ are defined as $\gamma_\mu = \beta\alpha_\mu$ for $\mu = 1, 2, 3$, $\gamma_4 = \beta_4$ where $\alpha_1, \alpha_2, \alpha_3$, and β are the Dirac matrices. The self-energy is then represented as

$$\Delta m = \frac{e^2}{\pi i} \int \sum_{\mu=1}^{4} \gamma_\mu (p + m - k) \gamma_\mu \left[(p-k)^2 - m^2\right]^{-1} k^{-2} \, d^4k$$

taken between the initial and final states, where we must integrate over all quantum momenta **k**. The symbol d^4k means

$dk_1\, dk_2\, dk_3\, dk_4/(2\pi)^2$. This integral, as mentioned previously, is divergent. The modification proposed by Feynman is to replace $1/k^2$ by $\int_0^\infty -[\lambda^2 G(\lambda)/k^2(k^2-\lambda^2)]\, d\lambda$. The auxiliary conditions $\int_0^\infty G(\lambda)\, d\lambda = 1$ and $\int_0^\infty \lambda^2 G(\lambda)\, d\lambda = 0$ are found to be necessary. After alteration in this manner the integral can be evaluated.

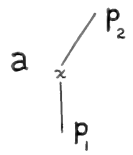
We shall understand in the following that the integral over λ with weight factor $G(\lambda)$ is to be performed later. The self-energy is

$$\triangle m = m\, e^2/2\pi \left[\tfrac{3}{2} \ln(\lambda^2/m^2) + 3/4\right]$$

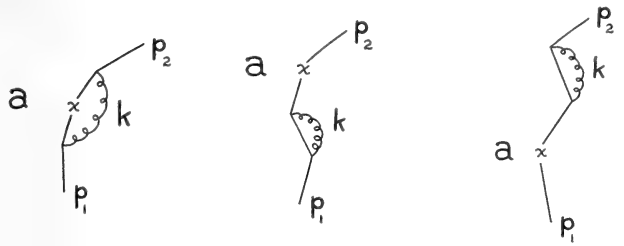
This is finite. That is we presume that the integral of $\triangle m\, G(\lambda)\, d\lambda$ over all λ is finite.

Let us now see how this solution may be used to reduce to a finite value the results of other processes similar to the Lamb shift.

The scattering of an electron in a potential field can be represented by the absorption of a quantum as we have already seen. Hence in our new notation a scattering looks like



where **a** is the scattering potential. We interpret this as the absorption of a quantum of momentum **q** and hence obtain $\mathbf{p}_2 = \mathbf{p}_1 + \mathbf{q}$. We assume the potential is of the form $A = \sum_\mu a_\mu \gamma_\mu e^{i\mathbf{q}\cdot\mathbf{x}}$ The zero order matrix element for the process is simply the matrix element of **a** between the states 1 and 2. The next higher order is the one involved in a Lamb shift process. Here we have in addition to the scattering, the emission and subsequent absorption of a virtual quantum by the electron. This may occur in any of the following ways



(a) (b) (c)

The resulting matrix elements diverge. But if we take the difference between the foregoing processes and similar ones for (b) and (c) with the quanta replaced by $\triangle$m, the result of this calculation is convergent and independent of the cut-off λ. This method is of great advantage in the calculation of processes involving virtual quanta.

The author has calculated the self-energy to the next higher order in e^2 (1951). That is the process in which 2 virtual quanta are emitted and then absorbed by the emitter.

The result of this calculation is

$$\triangle m \text{ (4TH order)} = m \frac{e^4}{4\pi^2} \left[-\frac{19}{8} \ln^2 \frac{\lambda^2}{m^2} + \frac{7}{12} \ln \frac{\lambda^2}{m^2} \right]$$

to order $\ln \frac{\lambda^2}{m^2}$

This result is encouraging in that it behaves as $\ln^2 \frac{\lambda^2}{m^2}$ in the leading term. It is somewhat discouraging in that it can not be simply expressed in terms of the second-order term already calculated.

There is still a great deal of work to be done on this problem. It is to be hoped that at some time we shall find a method of calculating the self-energy, and other higher order processes to all orders at once, in a finite invariant manner.

The Feynman theory, while providing a simple method of expressing the matrix elements, necessarily still involves the evaluation of integrals of very great complexity in the higher order terms.

It is not clear at present whether the difficulty is traceable to our mathematical methods or whether nature itself is really too complicated to be made simple.

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AN INVESTIGATION OF NATIVE FLORIDA MALE SALIENTIA AS TEST ANIMALS FOR EARLY PREGNANCY DIAGNOSIS

Keith L. Hansen
Stetson University

A Boston physician, Stanley L. Robbins (1948) began a paper dealing with the various pregnancy tests thus, "It is remarkable that a condition so essentially benign and self-limited as pregnancy, which must inevitably become obvious in the due course of time, has evoked so much interest in its early diagnosis." Today the existing tests for pregnancy may be classified into three main categories: biological assays, chemical assays, and skin tests. Of these three, the biological tests are the only method which has proved accurate and reliable. The biological assays for the determination of early pregnancy are based on the fact that pregnancy urine contains hormones which stimulate the gonads of certain of the lower animals.

The earliest test of this nature was the Aschheim-Zondek (1928) test of 1928. This test employed the female mouse and later the female rat as test animals. In 1931 a modification of this first test was made by Friedman (1931), using the female rabbit. The amphibian was utilized for the first time by Shapiro and Zwarenstein (1934) in 1933. These investigators found that the female South African clawed frog, *Xenopus laevis*, could be used in early pregnancy determination.

In March, 1947 Carlos Galli-Mainini (1947) first showed that the male South American toad, *Bufo arenarum* Hensel, would react to the gonadotropic hormone of pregnancy urine by the release of sperm. Since that date males of the following species of salientia have been used for this test: *Xenopus laevis* used unsuccessfully (Robbins, S. L., and Parker, F., 1948); *Rana pipiens* (Wiltberger, P. B., and Miller, D. F., 1948); *Bufo paracnemis, Bufo marinus, Bufo crucifer, Calyptocephala gayi, Leptodactylus ocellatus, Odontophrynus* sp., and *Bufo d'orbigny* (Galli-Mainini, C., 1948); *Bufo americanus* and *Bufo woodhousii* (McCallin, P. F., and Whitehead, R. W., 1949); *Bufo melanostictus, Bufo stomaticus,*

and *Rana tigerina* (Bhaduri, J. L., and Bardhan, N. R., 1949); *Bufo vulgaris* (Klopper, A., and Frank, H., 1949); *Bufo viridis* (Sulman, F. G., and Sulman, E., 1949); *Bufo bufo* (Haines, M., and Ferreira, H. P., 1949); *Rana vittigera* (Keegan, H. L., and Stonesifer, P. S., 1950); *Bufo boreas halophilus* (Johnson, D. A., 1950); *Rana clamitans* (Marsters, R. W., 1950); *Bufo regularis* (Rousselot, R., 1950); and certain common French amphibians (Creze, J., 1949).

Because of the ever increasing number of salientia being used as test animals in the diagnosis of pregnancy, the writer was interested in the possible use of frogs and toads native to Florida.

The species were selected as to their relative abundance and their general size. A few tests were made on *Hyla gratiosa* and positive results were obtained using both commercial chorionic gonadotropin and pregnancy urine. However, a smaller species of this type proves rather unpractical for the technique. This is the first attempt to use a species from the family Hylidae. Collections were made at night by blinding the frogs with a bright carbide light. As all species used (Table 1) possessed distinguishing secondary sexual characteristics, sex determination was relatively simple. The males of *Rana catesbeiana, Rana clamitans, Rana grylio,* and *Rana heckscheri* were identified by their tympanum, this being larger than the eye in the male of each of these species. The swollen and darkly pigmented thumb distinguished the male *Rana pipiens sphenocephala.* The male of *Bufo terrestris* was recognized by its darkly pigmented throat, whereas this sex in *Scaphiopus holbrookii holbrookii* was identified by the black horny excrescences on the thumb and first finger. Frogs and toads

TABLE I

Results of Tests Using First Trimester Pregnancy Urine

Salientia	Cubic Centimeters of Urine Injected	Length of Body of Test Animals in Millimeters	Positive	Negative
Bufo terrestris	3	50 – 65	20	1
Rana catesbeiana	5 – 10	101 – 130	17	3
Rana clamitans	5	64 – 73	13	0
Rana grylio	5	76 – 98	21	1
Rana heckscheri	5	76 – 91	8	0
Rana p. sphenocephala	5	56 – 73	16	0
*Rana p. pipiens**	5	60 – 72	20	0
Scaphiopus h. holbrookii	3	55 – 69	0	36

* This subspecies was obtained from northern biological supply houses.

were usually stored in small mesh-wire cages, where water was accessible. In some instances frogs were stored under refrigeration at approximately ten degrees centigrade. By this method frogs were successfully held from two to four weeks without feeding.

The technique is quite simple. Depending upon the size of the frog, three to ten cubic centimeters of first trimester pregnancy urine (Table 1) was injected subcutaneously into the dorsal lymph sac of the test animal. The amphibian was then placed in a large clean jar with a perforated lid. Two to five hours later this jar was examined for urine voided by the animal. If no urine was present, a small pipette was introduced into the cloacal orifice and cloacal fluid obtained by aspiration. Urine, taken either from the jar or directly from the frog, was then examined microscopically for the presence of spermatozoa. As seen under reduced light, the sperm appear as elongate cylindrical bodies, somewhat cigar shaped in form. Under the phase microscope, the long, slender, tails of the sperm are easily observed. The presence of sperm indicates a positive result, or pregnancy, while the absence of sperm shows a negative result. In the positive cases the sperm were heavily concentrated in the microscopic field giving a clear and definite end point. Exception to this was found in the *R. catesbeiana* where the sperm concentrations were rather weak. As few as two or three sperm were found in the high power field. There is some likelihood that seasonal variation and large size may effect the sensitivity of *Rana catesbeiana* and even *Rana grylio*. Continued studies are being made on these problems. Controls were made by using male and non-pregnant female urines. No sperm were ever found as a result from these injections. Also, each amphibian's urine was inspected for the presence of sperm previous to injection as a second manner of control.

Five native salientia proved reliable as test animals for early pregnancy diagnosis (Table 1). A total of 120 tests were performed on the first seven anurans, resulting in 115 positive tests and five negative tests. The single exception of *Bufo terrestris* was probably due to a low hormone concentration in the pregnancy urine used. Although *Rana catesbeiana* is questionable in its reliability, *Scaphiopus h. holbrookii* proved totally unreliable. Thirty-six tests made on the spadefoot toad yielded total negative

results as no sperm were ever found. Careful examination of this spadefoot's urine for sperm from one to eight hours after injection proved futile. Apparently seasonal variation does not effect this subspecies as separate groups collected and tested in May and October gave identical negative results. The latter group was collected while breeding. Animals from both groups were sacrificed, opened and their testes examined for sperm. Motile sperm were found in each specimen. In every case careful controls were made, identical urine being injected in the spadefoots and the control animals, *Rana p. sphenocephala*, *Rana grylio*. However, the toads consistently yielded no sperm while the controls proved positive. Although commercial chorionic gonadotropin brought about the abundant release of spermatozoa in the *Rana clamitans*, *Rana grylio*, and *Rana p. sphenocephala*, no similar effect was obtained with *Scaphiopus h. holbrookii*. Five of these toads injected with this hormone, in amounts of 100-250 rat units per toad, resulted negatively.

To date some twenty-three or more species and subspecies of male salientia, in addition to the five as reported in this paper, have been reported as responding to the gonadotropic hormone in pregnancy urine by the release of spermatozoa. These results would seem to indicate that this response is a generalized phenomena peculiar to male frogs and toads excepting *Scaphiopus h. holbrookii*, and thereby offers a practical means of early pregnancy determination. It is interesting to note that the spadefoot toad belongs to the Family Scaphiopodidae, a group of anurans heretofore untried for pregnancy diagnosis. Thus far, only species from the Families Pipidae, Bufonidae, Leptodactylidae, and Ranidae had been used as test animals for human pregnancy diagnosis. It should prove worthwhile to further investigate this family of spadefoots, the possibility being that others are also insensitive to the chorionic gonadotropic hormone.

Appreciation is given to two local physicians of DeLand for their cooperation in providing pregnancy urine used in this experimentation. Apologies are made to those authors whose work was unintentionally omitted from the history of this paper.

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ADDITIONS TO THE MOSS FLORA OF FLORIDA [1]

Ruth Olive Schornherst

The Check List of Florida Mosses (Schornherst, 1943), listed 265 species and varieties occurring within the state. Since that time further collections have added six species to the known moss flora of Florida. Although this list is short, it seems wise to publish the following supplement to the check list for the benefit of bryologists both within and outside Florida who are concerned with problems of distribution. Known county records are given to aid in the location of the species, so that further collections may be made from these counties and that careful attention be given to neighboring ones for extension of range.

Nomenclature of the *Sphagnaceae* follows that of A. L. Andrews (1940). All other species are cited in accordance with A. J. Grout (1940).

Sphagnaceae

Sphagnum compactum DC

Liberty, Santa Rosa

This species is circumboreal, and occurs throughout the southern states. It has not been reported from peninsular Florida.

Sphagnum capillaceum (Weiss) Schrank

Leon, Nassau, Putnam

Occurs frequently throughout the southeast, but not common toward the coast.

Pottiaceae

Gyroweisia Barbula (Schwaegr.) Paris

Alachua, Gadsden, Madison, Wakulla

Known from the West Indies, Bermuda, Bahamas, and British Honduras. Except for the collections cited here, it is not known from the United States.

Hypnaceae

Brachythecium Pennellii Bartram

Wakulla

This interesting species is known only from the State of Nuevo Leon, Mexico, and from two stations in Texas, where it is closely associated with limestone. The Florida collection is from a limestone area, although the specimen was growing on soil.

Vesicularia vesicularis (Schwaegr.) Broth. var. *Poppigiana* (Hampe) Broth.

Orange, Seminole

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[1] Contribution number 43, Botanical Laboratory, Florida State University.

LESKEACEAE

Thuidium recognitum (Hedw.) Lindb.

Dade, DeSoto, Hernando, Lake, Polk

This is typically a species of more northern regions. A number of specimens collected in Florida and bearing this label have been examined, but proved to be *Thuidium delicatulum* (Hedw.) Mitt. Those cited here have been checked by Mr. Paul Refrearn, who has devoted considerable time to the study of the bryophytes of the Polk County region, and by Dr. A. J. Sharp, University of Tennessee, and there seems to be no reason to doubt their identification.

FONTINALACEAE

Fontinalis disticha Hook. and Wils.

Gadsden, Leon

Reported from most of the eastern and southern states, but not recorded previously from Florida.

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ECTOPIC PANCREATIC TISSUE IN THE STOMACH WALL OF AN ALBINO RAT[1]

Perihan Cambel and Cecelia Conroy

The fortuitous occurrence of accessory pancreases along the human gastrointestinal tract is well known (Cambel, 1936). In their review and morphological investigation on accessory pancreatic ducts of the major duodenal papilla in the human, Loquam and Russell (1950), pointed out the difficulty in readily distinguishing neoplastic from non-neoplastic epithelial cells in this location. The same difficulty can be encountered in other parts of the gastrointestinal tract and in other species. Therefore, the accidental observation of heterotopic pancreatic tissue in the stomach wall of an albino rat during the course of an experiment (Conroy, 1950) will be reported.

Experimental Material and Procedures

The lesion to be reported was found in a female albino rat out of 36 Sprague-Dawley-Holtzman rats (18 females, 18 males). The control group was composed of 6 female and 6 male animals. After conditioning the rats to pipette feeding with water, the experimental animals (12 females, 12 males) were caged individually without water supply. They were fed daily with 24 ml. of a 0.1 per cent and 6 ml. of a 1 per cent aqueous eugenol emulsion. The first experimental group was fed eugenol for a one week period and sacrificed on the seventh day, while the second experimental group was fed eugenol for about four weeks and sacrificed on the thirtieth day. All animals were fasted 36 hours prior to sacrifice to assure a resting stomach. Daily eugenol feeding of the experimental animals was continued during the fasting period, while the control group was provided with water *ad libitum*.

The eugenol emulsion was made up according to Kraus and Hollander (1949) in a Waring blendor. Tergitol-Penetrant (1/50

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[1] A contribution from the Cancer Research Laboratory, University of Florida, Gainesville, Florida.

This study was supported by Grant C-976 of the National Cancer Institute, U. S. Public Health Service.

per cent) was used to stabilize the emulsion. The pH of the emulsion was 8.25.

The stomachs of all rats were cut according to our standard procedure (Cambel and Sgouris, 1951) and fixed in a mixture of absolute alcohol and formalin for microincineration (Conroy, 1950). Paraffin sections cut at 5μ were stained with hematoxylin and eosin, Van Gieson, Meyer's mucicarmine as modified by Cowdry (1948) and the periodic-acid-Schiff reaction (PAS) after McManus (1948).

Case Report

A female rat of the second experimental group weighed 155 gm. at the onset of the experiment, and 142 gm. at the end. Her age was 2 months at the onset and 3 months at the end of the experiment.

At autopsy, the abdominal fat was lacking. Other gross changes noted were reduction in size of the thymus, hyperemia of the liver, hypertrophy of the spleen, decrease in number and size of Peyer's patches, and atrophy of the mucosal folds in the glandular stomach. The pH of the glandular stomach taken with Alkacid paper was 6, while that of the forestomach was 5.

Histological Findings in the Stomach: In three alternate sections of Zone I (Cambel and Sgouris, 1951), ring-like and rudimentary acinar structures were seen lying in the sub-mucosa, in a defect of the muscularis, and in the muscularis (Figs. 1, 2). The muscularis mucosae of the compound gastric mucosa in this region was thinner than in other regions, but continuous and intact except for a small interruption. Here a canalicular structure originating from the submucosal epithelial tissue opened into the pit of a gastric gland (Fig. 3). This canaliculus contained amorphous,

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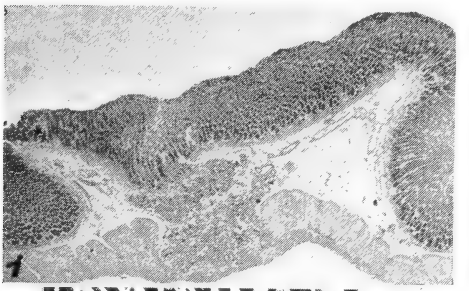
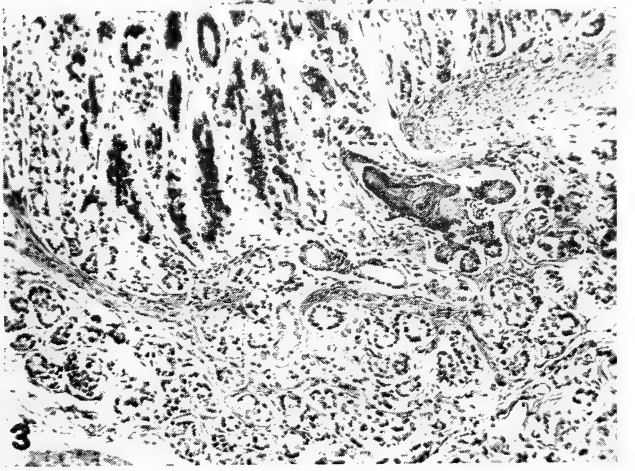
Figure 1.—Accessory pancreatic tissue in the stomach wall of an albino rat. The ectopic tissue fills out the partial defect in the muscularis and occupies the submucosa. Hematoxylin and Eosin. Magnification 24 ×.

Figure 2.—Accessory pancreatic duct tissue in the muscularis of the rat's stomach wall. Hematoxylin and Eosin. Magnification 125 ×.

Figure 3.—Pancreatic tissue in the submucosa of the rat's stomach. Rudimentary acini and small ducts are seen. The muscularis mucosae shows a small defect where one of the ductules, originating from four rudimentary acinar buds, opens into the pit of a stomach gland. The duct contains an amorphous, PAS-negative secretion, while some of its cells and some mucous cells of the stomach glands show the dark PAS-reaction. PAS reaction after McManus. Magnification 125 ×.





PAS-negative, slightly eosinophilic material. Some of the ring-like structures showed slight dilations. The ring-like structures were made up of low columnar or cuboidal epithelial cells with clear cytoplasms and regular, vesicular, slightly oval nuclei. Only very few of these cells gave positive mucicarmine and PAS reactions in the form of a few granules. The rudimentary acinar structures were composed of more polyhedral cells (Fig. 3). No mitotic figures were detected. The basement membrane in all parts of the stomach section was PAS-negative. The gastric glands of the mucosa above the heterotopia showed mostly PAS-positive mucous cells. In the other parts of the mucosa the glands were PAS-negative and only occasionally contained a few PAS-positive cells. The PAS-positive surface mucous cells were greatly reduced in their number and flattened. Only little PAS-positive surface mucous was observable.

The number of parietal cells in the compound mucosa seemed increased in number. Most of them showed conspicuous and some, widened intracellular canaliculi. The pepsinogen cells were present in all parts of the compound mucosa. The squamous cell epithelium of the esophageal orifice showed no particularities. That of the forestomach showed occasional warty excrescenses.

No peculiarities were observed in Zones II and III.

Diagnosis: Ectopic pancreatic tissue in stomach wall.

Comment

No case of heterotopic pancreatic tissue in the stomach of rodents comparable to the one described has been reported in the literature. Stewart (1951) and Hollander (1951) stated that they had not observed such lesions in mice or in rats, respectively. No other similar lesion has been seen so far in our laboratory, where routine examinations of the stomachs of rats and mice are made according to our standard procedure (Cambel and Sgouris, 1951).

The gross invisibility of the aberrant pancreas described contrasts with the obviousness of those observed in the human (Cambel, 1936; Opie, 1903; Koch, 1926; Moore, 1929). Its estimated size of about 30μ in length explains the difficulty of observing such lesions grossly in small rodents. Therefore, even their microscopic observation is a matter of pure chance. Unless complete serial sections of statistically valid numbers of stomach are studied, the incidence

of such lesions cannot be determined. Their presence may often escape notice, because only rarely complete serial sections of the stomach are made, such as by Roffo (1949, 1941a, 1941b).

The histological structure of the accessory pancreatic tissue was such that diagnosis was not evident on routine examination as in some human cases (Cambel, 1936; Opie, 1903; Koch, 1926; Moore, 1929). This is because the islands of Langerhans, the presence of which is known to vary in accessory pancreases (Koch, 1926; Moore, 1929) were absent. In addition, the acini were more or less rudimentary. Therefore, a differential diagnosis between accessory pancreatic tissue and accessory Brunner's Glands (Koch, 1926; Moore, 1929) had to be made.

We have observed that Brunner's Glands and their ducts give a very strong, generalized PAS-reaction (McManus, 1948) in rats, while pancreas is PAS-negative in the same species. Only a few cells in the excretory ducts sometimes showed a few PAS-positive granules. The same finding was observed in our aberrant epithelial tissue. Therefore, the diagnosis of accessory pancreas was made. In other cases of histological uncertainty or controversy such as the carcinoids (Koch, 1926; Moore, 1929), the histochemical reaction of McManus will be an important aid in arriving at the correct diagnosis and could settle the controversy. It should be, therefore, used for purposes of differential diagnosis in all pathology laboratories.

The literature cited by Koch (1926) and Moore (1929), their discussions of the histology and histogensis of heterotopic epithelial lesions in the gastrointestinal tract make it also obvious that our diagnosis is justified. Our case, therefore, could not be mistaken as either adenomyoma or carcinoma.

No causal relations could be seen between the eugenol administration and the accessory pancreas.

A review of the articles by Roffo (1949; 1941a; 1941b), and Cox *et al.* (1947), and a study of the reproductions of their microphotographs made us suspect that these authors might have mistaken some lesions consisting of ectopic pancreatic tissue without islands of Langerhans as carcinomas (Roffo, 1949, microphotographs No. 7 and 24, seem to show an intact muscularis mucosae, 13b, microphotograph No. 8 of rat 5399|40 also shows a heterotopic lesion under an intact muscularis mucosae, Cox *et al.*, 1947, Fig. 11).

The presence of ring-like or acinar structures in the submucosa, in a defect of the muscularis, and especially in the muscularis as seen in our case, might be easily mistaken for carcinoma, as pointed out by Loquam and Russell (1950). Koch (1926) dwells with emphasis on the irregularity that can often be observed in the arrangement of acini and canaliculi of accessory pancreases. This irregularity is obvious in the cases of Roffo (1949; 1941a; 1941b) and Cox *et al.* (1947). It probably resulted from the irritative proliferation of the ectopic tissues caused by the accompanying gastritis usually associated with ulcerous lesions, according to their microphotographs. This would lead us to believe that neither Roffo (1949; 1941a; 1941b) nor Cox *et al.*, (1947) were really able to induce experimentally gastric carcinoma in rodents. We do not doubt, however, the importance of these lesions in the formation of adenomyoma or carcinoma (Moore, 1929; Roffo, 1949; 1941a; 1941b). The serial sectioning of the stomach probably aided Roffo (1949; 1941a; 1941b) in obtaining a high incidence of ectopic pancreases.

The "epithelial inclusions" observed by Ivy and Cook (1947) may also be rudimentary forms of accessory pancreatic ducts.

In regard to developmental mechanics and histogenesis of accessory pancreases the reader can be referred to the excellent discussions of Koch (1926) and Moore (1929) on this subject. In this connection, we would like to point out the observations on the fetal presence of aberrant pancreases in the human stomach (Gardiner, 1907; Lewis, 1912). These do not support the view of Lubarsch cited by Koch (1926) that ectopic pancreases in the human can be regarded as acquired lesions because the majority are observed in advanced age. It is also interesting to note that Lubarsch discusses the structural changes in these lesions caused by fresh or older inflammatory processes.

As in all cases of dormant ectopic tissue, our case illustrates the fact that misplaced cells may remain in the body without showing signs of proliferative growth, even when an irritant like eugenol has been administered.

Summary

A case of aberrant pancreatic tissue in the stomach wall of an albino rat is described. The importance of correct differential diagnosis between ectopic and neoplastic epithelium is discussed in

view of "the arrangement of epithelial cells to stroma suggesting invasion of smooth muscle" (Loquam and Russell, 1950).

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OBSERVATIONS ON *LITTORINA ANGULIFERA* LAM. FROM BISCAYNE KEY, FLORIDA

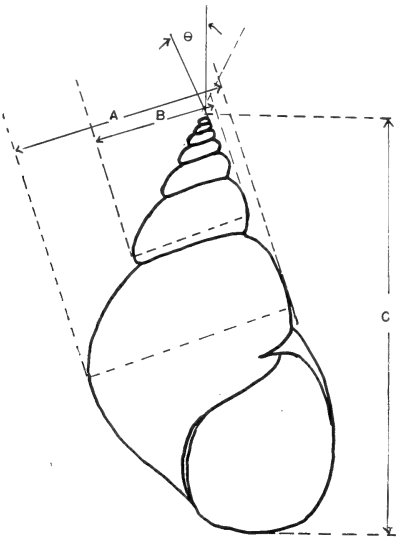
RUTH E. LENDERKING

I.—The Relation of Growth to Sex.

In searching the literature on Mollusca one finds very little indeed on the rate of growth. In the genus *Littorina* work has been done on *L. scabra*, by Sewell (1924), on *L. littorea* by Moore (1935), and on *L. irrorata*, by Newcombe (1936). This paucity of information is more pronounced for forms found in the tropics.

Ecological studies of *Littorina angulifera* were begun February, 1951, under the direction of Hilary B. Moore, University of Miami. This paper is a brief report of one phase of the work completed in May, 1951.

The sex of the snails was determined by the presence or absence of a penis. This is evident only in males of nine millimeters or more in height. Since unequal sex ratios seemed to indicate a varying



Measurements of *Littorina angulifera* Lam.:
θ—one-half the apical angle
A—the diameter of the last whorl
B—the diameter of next to last whorl
C—height of the shell

rate of development only snails of thirteen millimeters or more were considered in this study.

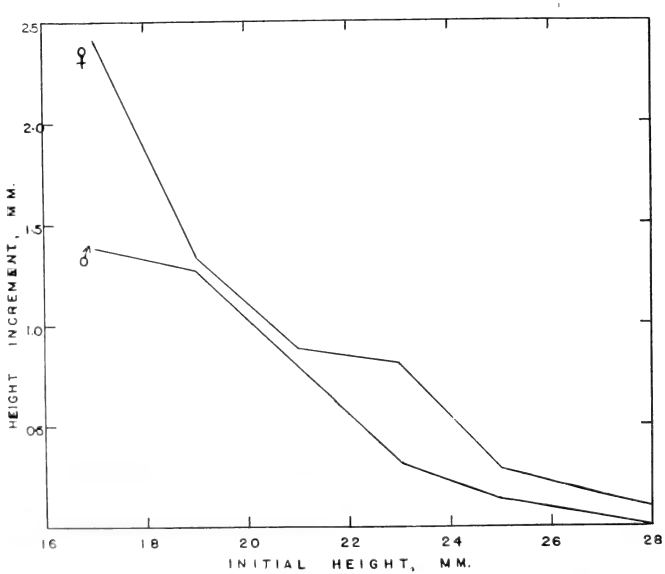
Over five hundred snails from a small area on the north end of Biscayne Key were collected through February and early March. The lip was notched with a rotary file and the snails returned to the same location. Of these, 192 (102 males and 90 females) were found usable in the study when collected on May 23, 1951.

Measurements were made of the height, the diameter of the last two whorls, the apical angle, and the lip increment from the healed notch. The accompanying diagram indicates how these measurements were taken.

The constant for the relationship of the spiral height to length was calculated from the formula:

$$\frac{L}{H} = \frac{\sqrt{1 + C^2}}{\cos. \theta}$$

where θ is one half the apical angle,



Graph showing shell increment of the females in comparison with the shell increment of the males in *Littorina angulifera* Lam.

$$C = \frac{2.73 \text{ SIN. } \theta}{\text{LOG. } Q}$$

and Q is the ratio of any two successive measurements 360 degrees apart. In this case the diameters of two successive whorls were used. This constant is necessary to compute the spiral height. By subtracting the lip increment, the original spiral height can be computed and the increase in height then determined.

The results of these computations are plotted on the accompanying graph. Though the sample was small there is a definite indication of a more rapid growth in the female population.

It is interesting to note that Moore (1935) found a similar difference in growth rate for male and female *Littorina littorea.*

Summary

In snails from the north end of Biscayne Key, female *Littorina angulifera* were found to grow faster than males in all adult sizes. The rate slows down above 18 millimeters, increasing again at 22 millimeters to 25 millimeters. The increment is constant from this size to the greatest height.

II.—The Sex Ratio in Adults.

In April and May of 1951 four hundred ninety-one snails of from 16 to 28 millimeters were collected and examined to determine the sex and the ratio of males to females. It was found that 50.6% of the population from 16 to 24 millimeters inclusive were males, while only 26.0% of those from 25 to 28 millimeters inclusive were found to be males. Comparable results were found by Sewell (1924) for *L. scabra,* and Moore (1935) for *L. littorea.*

The fact that the rate of growth is greater in the female would lead one to expect a preponderance of females in the larger size brackets. This is clearly shown to be a fact by the analysis of the adult snails for size and sex. The two studies described above complement each other and strengthen the evidence of greater growth in the females.

Summary

The percentage of males in the population of *L. angulifera* of 16 to 24 millimeters is 50.6%, while the percentage of males in sizes 25 to 28 millimeters is 26.0%.

Acknowledgments

The writer wishes to express appreciation to Dr. Hilary B. Moore for supplying the formulae used in computing the shell increment and for his kind assistance in preparing this paper.

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ON THE NATURAL HISTORY AND IDENTIFICATION OF SPIDERS [1]

H. K. Wallace

The purpose of this paper is to answer two questions: First, "how can I determine the name of this spider?", and second, "where can I learn about the ways of spiders?"

These two questions are sent in to various agencies connected with the University of Florida a dozen times a year. The answers to them should also be of interest to high school biology teachers and college teachers of ecology, invertebrate zoology, and many field courses.

Until quite recently the matter of identifying a spider to species has posed quite a problem to anyone not a specialist in the group. Prior to 1912 and the publication of Comstock's "Spider Book" there was no general work on American spiders that treated the spiders in such a way as to be very useful in classification. Most of the taxonomic information available was scattered in numerous articles in a large number of scientific journals. Comstock really did a magnificent job in producing an introductory manual to the study of Arachnology. His book starts out with a review of the groups of animals most closely related to spiders — the scorpions, the pseudoscorpions, the whip-scorpions, granddaddy-long-legs and the like. Then follow chapters on the external anatomy, internal anatomy, and life of spiders — necessary prerequisites to the successful handling of descriptions and taxonomic keys during identification procedures. The remaining 500 pages of the book are devoted to a survey of the spider Order Araneae in which all of the American families are described and many of the genera and species. Unfortunately, space did not permit the inclusion of information on all known species. Instead, Comstock selected representative or the more striking species and included, for these, descriptions, illustrations, interesting accounts of their habits, life histories, etc. This book was out of print for a number of years but was revised somewhat by W. J. Gertsch in 1940 and published by Doubleday, Doran & Company, Inc., New York. For a general introduction to American spiders this is probably the best selection for a beginning student. The book is well illustrated.

[1] A contribution from the Department of Biology, University of Florida.

As has already been indicated, Comstock is not satisfactory, because of its incomplete coverage, when it comes to the identification of a spider to species, and, indeed, there is no satisfactory book available for the whole United States. However, there is a very fine manual on the "Spiders of Connecticut" which, although it covers only the spiders of Connecticut and neighboring states, does contain descriptions, keys and illustrations of many of the spiders in any of the eastern states. It is very useful, for example, in the determinations of Florida species. Even if a particular species is not included in the manual it is usually possible to identify it to genus. This book contains excellent keys to the families, to the genera, and to the species, and is abundantly provided with illustrations of the structural features upon which the identifications to species are made. The "Spiders of Connecticut" is the work of Dr. B. J. Kaston of the Teachers College of Connecticut in New Britain, and was published in 1948 as Bulletin No. 70 of the State Geological and Natural History Survey. It may be purchased from the State Library in Hartford.

A great many spiders, then, may be identified with the aid of the books by Comstock and Kaston. As a last resort specimens may be sent to the American Museum of Natural History in New York for identification. Dr. W. J. Gertsch, Curator of Arachnology of that institution, has given me permission to include a statement to the effect that he will be glad to receive specimens in limited numbers for identification. In return for the time involved important specimens are retained by the Museum and only duplicates returned. Retained specimens are properly acknowledged. I may say from personal experience that specimens sent to Dr. Gertsch are handled promptly.

Most people appear to grow up with an antipathy for spiders that ranges all the way from a slight feeling of distaste to paralyzing fear and revulsion. It is one of those traditions that are handed down from generation to generation without having any foundation in fact. Very few spiders are poisonous to man anywhere on the globe and in the United States only the black widows are known to produce any serious effects, and these are seldom, if ever fatal.

Mention of one other widespread misconception seems appropriate. Far from being the ugly repulsive beast of fable, spiders as a group are quite respectable in appearance. Many are handsomely

colored. Of course it all depends upon your point of view. For those to whom the word "spider" calls to mind only a picture of the hairy, drab colored tarantula, revulsion is understandable. One has to see the rich variety of color and the perfection of the anatomical design in order to appreciate the real beauty of spiders. Unfortunately, this requires the use of a hand lens or even low power binocular microscope in all too many cases.

This widespread feeling about spiders is unfortunate because it precludes an acquaintance with a group of animals that has much to offer in the way of biological interest. Anyone who enjoys a stroll through the fields and woods would do well to strike up an acquaintance with this almost inexhaustable supply of variety in life and habits. Population densities have been calculated to range, in different regions, from 14,000 to over 2 million per acre. No counts have been made for Florida but it is certain that spiders are very numerous. As to kinds, there are probably about a thousand species in Florida, with many of these yet undescribed.

As one of the oldest of the groups of animals related to the insects, spiders have had a great length of time at their disposal in which to devise new and curious ways of making a living. Starting out with a copyright on the use of silk (which has been infringed only on rare occasions) spiders have put this material to almost every conceivable use. To mention only a few — for "ballooning", traveling long distances through the air supported by strands of silk; for snares with which to capture their prey (the variety of these is unbelievable!); for protective coverings around the eggs; as a lining of the burrow to prevent cave-ins; for a variety of kinds of doors at the entrance to burrows.

A large number of books have been written on the subject of the life and habits of spiders. Many of these are out-of-print or otherwise unavailable. Some of those still in print, unfortunately, smack of authenticity to the non-specialist, but in reality represent the worst form of nature-faking. The following list of selected titles is arranged according to their availability and desirability as sources of reliable information. The first two are recommended for purchase, the others should be looked for in larger public libraries. Comstock's Spider Book should be in this list, but has already been listed above.

American Spiders. By Willis J. Gertsch. D. Van Nostrand Company, Inc., New York. 1949.

The Life of the Spider. By J. Henri Fabre (translated by Alexander Teixeira de Mattos). Blue Ribbon Books, Inc., New York. 1912. (Note: any edition of the work of the great French naturalist would serve just as well).

The Comity of Spiders. By William S. Bristowe. Printed for the Ray Society of London. Vol. 1—1939. Vol. 2—1941.

American Spiders and their Spinningwork. By Henry C. McCook. Published by the author. Vol. I—1889. Vol. II—1890. Vol. III—1894.

The Biology of Spiders. By T. H. Savory. Sidgwick & Jackson, London. 1928.

Spider Wonders of Australia. By K. C. McKeown. Angus & Robertson Limited, Sidney. 1936.

One due to appear in the very near future is: *How to Know the Spiders.* By B. J. Kaston. The William C. Brown Co., Dubuque, Iowa.

Additional titles may be found in the bibliographies of the works listed above.

THE RESPONSES OF MALE SALIENTIA TO HUMAN CHORIONIC GONADOTROPIC HORMONE

James C. Knepton, Jr.
Wesleyan College

Robbins, Parker, and Bianco (1947) have demonstrated that male *Xenopus laevis* Daudin react to the chorionic gonadotropic hormone by the emission of spermatozoa. Samson (1950) studied the variation in sensitivity of male *Rana pipiens* to chorionic gonadotrophin. Other investigators have similarly studied the reaction of various salientia. Bhaduri (1950) has an excellent summarization of work done in this field.

The present investigation was designed to study comparatively the responses of males of five native species of Florida salientia to the human chorionic gonadotropic hormone. The species selected for this experiment represent five families of Salientia. Studies were made with animals collected throughout the year (calendar year, 1950) in order to evaluate any seasonal effects. Correlative histological studies of the testes of the experimental animals were also undertaken.

Acknowledgments

This research was aided by the generosity of Dr. Samuel M. Gordon, Endo Products Incorporated, Richmond Hill, New York, who supplied his company's packaged commercial human chorionic gonadotropic hormone, ENTROMONE. The chorionic gonadotropic hormone international standard was graciously contributed by Dr. Lloyd O. Miller, Director of Revision, Committee of Revision of the Pharmacopoeia of United States of America.

Miss Thelma Howell, Wesleyan College, gave constructive suggestions during the preparation of this paper and kindly loaned her Bausch and Lomb filar micrometer for the measurement of spermatozoa.

The nature of this research demanded the nearly continual collection of specimens. My thanks are due Messrs. Byrum Cooper, Robert Hellman, and Thomas Stewart for their helpful contributions of material. Mr. Edwin H. McConkey collected specimens from September until December, 1950, which enabled me to finish

a year's observation on this particular problem even though I was not residing in Gainesville during this period. His aid is highly appreciated.

I am most grateful to Dr. Arnold B. Grobman, University of Florida, under whose guidance this research was executed.

And finally I wish to express my appreciation to Drs. C. J. Goin, L. G. Gramling, H. T. Odum, H. K. Wallace, and E. S. Ford, University of Florida, who have given of their time and advice to various phases of this problem.

Materials and Methods

During the calendar year of 1950, male frogs were collected each month in the vicinity of Gainesville, Florida. From January to September the collections were made by the writer and from September until the end of the year five males of each species being studied were furnished by Mr. McConkey. The number of specimens of each species collected by the writer is given in Table I, the data being roughly indicative of the availability of each species.

TABLE I

Number of males of native Salientian species collected in 1950.

Species	Jan.	Feb.	Mar.	April	May	June	July	Aug.
Scaphiopus h. holbrookii	10	0	6	7	7	6	0	5
Bufo t. terrestris	1	0	14	23	23	34	4	14
Hyla c. cinerea	3	0	2	8	4	18	0	6
Rana pipiens sphenocephala	6	0	5	10	7	8	0	1
Microhyla carolinensis	0	0	0	2	1	21	8	19

Collecting was done at night for *Scaphiopus h. holbrookii* (Harlan), *Bufo t. terrestris* (Bonnaterre), *Hyla c. cinerea* (Schneider), and *Rana pipiens sphenocephala* (Cope). *Microhyla carolinensis* (Holbrook) was collected during the daytime.

Following each collection the individual frogs were placed in separate jars covered with a gauze top.

The frogs were measured for snout-vent length with a millimeter ruler, to the nearest millimeter, and were weighed with a trip balance to the nearest tenth of a gram.

The commercial chorionic gonadotropic hormone was used for this investigation in preference to a hormone-containing substance such as urine of pregnant women. The pure hormone has the very distinct advantage of eliminating a number of variables: the amount of hormone is known and the purity of the hormone is relatively constant.

Each package of human chorionic gonadotropic hormone contained a 10 cc. rubber-stoppered, multidose vial with 5,000 International Units of dehydrated hormone and an ampule filled with 10 cc. saline solution. When the dehydrated hormone was diluted, each cc. of aqueous solution contained 500 I. U. of chorionic gonadotropic hormone.

The commercial chorionic gonadotropic hormone was checked against the chorionic gonadotropic hormone international standard which is produced by the United States Pharmaceutical Reference Standards, New York City. The same results, both qualitatively and quantitatively, were obtained from frogs injected with the standard hormone and from those injected with the commercial hormone.

The injection of the frogs with the chorionic gonadotropic hormone was usually done a day or two after collection. Urine from each frog was inspected to determine whether spermatozoa were present before injection with the hormone. The urine samples were obtained by a method of "milking". "Milking" is accomplished by holding the frog in the hand with his head in the palm and the area of his cloaca held between the thumb and forefinger. Urine is then forced from the frog's bladder with the thumb and forefinger.

A 1 cc. syringe with a 27-gauge needle was used for injection purposes. While the dosages varied they were easily controlled as the original dilution resulted in 50 I. U. of chorionic gonadotropic hormone in each 0.1 cc. solution. The injections were made subcutaneously into the dorsal lymphatic sac of the salientians.

Following injection, each frog was returned to his jar. Urine samples were taken approximately one-half hour after injection and subsequently thereafter, usually at half-hour intervals when convenient, until spermatozoa were observed. With each series of injections, parallel observations were made on an uninjected control frog of the same species.

Each month the testes from an injected and control frog were removed and fixed in Bouin's fluid and later prepared for histological study. The paraffin method and an alcohol series were used in preparing the tissues. The 10-micron sections of testis were stained with iron hematoxylin and eosin and mounted with balsam. For final observations the oil immersion objective was used. The length of the spermatozoa in the testis of each species of frog was measured from the prepared slides with a Bausch and Lomb filar micrometer.

Results

Scaphiopus holbrookii holbrookii (Harlan). Family Pelobatidae. With the exception of the month of February when no specimens of this toad were found, males of this species were easily collected from January to July. Throughout July no specimens were found although an intensive search was made. In August collections were adequate for experimental purposes (see Table 1).

The adult males ranged in snout-vent length from 42 to 71 millimeters. The variations in weight were from 6 to 30 grams.

Forty-five specimens were injected with amounts of chorionic gonadotropic hormone ranging from 25 to 250 I. U. At approximately 30 minute intervals urine samples were examined for discharged spermatozoa until 36 hours following injection. The examinations were in vain. Under the conditions of this experiment spermatozoa were not discharged. An explanation of this negative result, which apparently involves the biological effect of atmospheric pressure, is being prepared for presentation elsewhere.

In injected and control Spadefoot Toads the most advanced stage of spermatogenesis found in abundance from March until May was the leptotene stage. From May until November all stages could be found in relatively the same abundance. The average length of the head of the spermatozoa of this species is 6.0 microns.

Bufo terrestris terrestris (Bonnaterre). Family Bufonidae. Male specimens of the Southern Toad were easily collected from March until September at the edges of ponds, lakes and small streams. The group used for tests varied in snout-vent length from 45 to 71 millimeters and weighed from 7 to 27 grams.

One hundred and four male specimens were injected with from 12.5 to 200 I. U. of the chorionic gonadotropic hormone. One hundred and two specimens reacted positively to the hormone by

discharging spermatozoa into the urine. Two specimens reacted negatively. Spermatozoa were not found in the urine samples from the controls. If spermatozoa were present in the urine, they always appeared in large numbers. Southern Toads injected with 50 to 200 I. U. of the chorionic gonadotropic hormone reacted by demonstrating nervousness along with the ejection of spermatozoa into the urine. Spermatozoa were first observed in urine samples as early as 25 minutes and as late as 149 minutes after injection.

Throughout the year, all stages of spermatogenesis were observed in the testes of both injected and control animals. In addition, there was an abundance of spermatozoa detached from the vacuolated Sertoli cells of the injected specimens. In the testes of the control frogs, it was observed that during August, September, and October spermatogenic figures in the pachytene and diakinesis stages are more frequent than those of the other stages. Among the controls it was also noted that spermiogenesis occurs the entire year and that spermatogonia are few in May and June.

The spermatozoa of *Bufo t. terrestris* averages 10.9 microns in length of head.

Hyla cinerea cinerea (Schneider). Family Hylidae. Male specimens of *Hyla c. cinerea* were collected during the months of January, March, June and August, 1950. The adult male specimens ranged in snout-vent length from 28 to 57 millimeters. They varied in weight from 1 to 9 grams.

The doses of chorionic gonadotropic hormone injected into male specimens of *Hyla c. cinerea* varied from 12.5 to 250 I. U. Spermatozoa were discharged by thirty of the thirty-four individuals. Spermatozoa were first observed in urine samples as early as 41 minutes and as late as 261 minutes following injection. This reaction did not appear in the controls. In addition to exhibiting nervousness, the injected frogs turned from their natural green color to a dark green and their hind legs turned black.

Prepared sections of the testes from injected and control specimens exhibited the same characteristics. The testes are yellow and average 10 to 12 millimeters in length. During each month of the experiments with this frog (January, March, June, and August) spermatogenic figures were present. Meiotic figures in the first division were abundant in August. In April and May, stages of the second meiotic division were more abundant.

Spermatozoa were always present in the lumina of the seminiferous tubules of the testes from injected specimens. The Sertoli cells when vacuolated had no spermatozoa attached to them.

The length of the head of the spermatozoon of *Hyla c. cinerea* averages 9.0 microns.

Rana pipiens sphenocephala (Cope). Family Ranidae. This species was found along the banks of small streams in the cooler periods of the year. During the warmer months, April to October, they were present at the banks of large bodies of water.

The snout-vent lengths for adult males of this species ranged from 47 to 72 millimeters. Their weights varied from 7 to 28 grams.

Thirty-two of the thirty-five specimens of the Southern Leopard Frog reacted positively to amounts of chorionic gonadotropic hormone varying from 25 to 250 I. U. In positive cases, abundant spermatozoa were discharged 27 to 167 minutes following injection with the hormone. Besides ejecting spermatozoa after injection, the medial side of the hind legs of this species turned black. Urine from the controls of this species contained no spermatozoa.

The testis of *Rana pipiens sphenocephala* is yellow and measures approximately 10 to 11 millimeters long and 3 to 4 millimeters in diameter. The individual seminiferous tubule is relatively small and filled with spermatogenic cells and spermatozoa. Various stages of spermatogenesis were present all year in both injected and control frogs.

The lumina of the seminiferous tubules in the testes of injected frogs were filled with spermatozoa detached from vacuolated Sertoli cells. The lumina of the control frogs were empty because spermatozoa were attached to the Sertoli cells. During January the walls between the seminiferous tubules of both injected and control specimens were thickened by the presence of many interstitial cells. During other months in which tests were made the number of interstitial cells was greatly reduced.

The average length of the head of a spermatozoon of this species was found to be 13.0 microns.

Microhyla carolinensis (Holbrook). Family Brevicipitidae. The first intensive collecting for this species was done in April and specimens were obtained from then until October (see Table I). The male Narrow-Mouth Toads varied in snout-vent lengths from 21 to 31 millimeters and in weight from 0.6 to 2.6 grams.

Forty-five specimens of this species were injected with amounts of chorionic gonadotropic hormone varying from 12.5 to 50 I. U. Forty-one of the Narrow-Mouth Toads reacted by discharging spermatozoa from 45 to 161 minutes after injection with the hormone. The toads reacted to the hormone in another manner besides discharging spermatozoa. After injection with any dosage of chorionic gonadotropic hormone, their bodies would move spasmodically and they apparently had no control of any muscular movement. Spermatozoa were found in the urine of injected Narrow-Mouth Toads in large quantities but they did not occur in the urine of the controls.

In relation to others studied, the testis of this species is relatively small. Sections of testis from a Narrow-Mouth Toad collected in April showed very few spermatogenic cells beyond the preleptotene and leptotene stages. From May until September the sections of testes demonstrated the abundant occurrence of all stages of spermatogenesis. A noticeable decline in the number of cells in advance meiotic stages was evidenced from the sections of testis of a toad collected in September. In all the testes removed from injected toads spermatozoa were detached from the vacuolated Sertoli cells. Sections of testes of control toads showed spermatozoa attached to non-vacuolated Sertoli cells.

The head of a sperm cell of *Microhyla carolinensis* averages 9.0 microns in length.

Discussion

The percentages of positive results obtained by injecting the various toads and frogs with chorionic gonadotropic hormone are shown in Table 2. These percentages are derived from healthy specimens that were injected with non-toxic doses of hormone. The non-conformities are discussed below.

Scaphiopus h. holbrookii does not react positively to the chorionic gonadotropic hormone under the conditions of the present experiments. The possible reasons for the negative reaction will be considered in a forthcoming report.

Two injected males of *Bufo t. terrestris* did not react, presumably due to the toxic nature of large dosages. It may naturally be that a heavy frog needs a large dose and a light frog a relatively smaller dose.

TABLE II

Percentages of native male Salientia discharging spermatozoa after being injected with human chorionic gonadotropic hormone.

Species	Total number of frogs injected.	Number of adult frogs in good health injected with less than toxic but more than minimal dosage.	Number of negatives from column 2.	Percent positive.
Scaphiopus h. holbrookii	45	45	45	0
Bufo t. terrestris	104	102	0	100
Hyla c. cinerea	34	30	0	100
Rana p. sphenocephala	35	32	0	100
Microhyla carolinensis	45	43	2	95.3

Four individuals of *Hyla c. cinerea* injected with the chorionic gonadotropic hormone did not discharge spermatozoa. It is believed that these specimens were possibly given too large a dose of hormone (2 received 200 I. U.; 2 received 100 I. U.) for the emission of spermatozoa. However a single specimen also injected in April with 100 I. U. reacted positively. But it took this specimen 261 minutes to react which was the longest reaction time observed during the entire study of this frog. The same dosage, causing both negative and positive responses, may indicate that 100 I. U. is a critical level and that lower doses should be used.

The explanation for a specimen of *Rana pipiens sphenocephala* which reacted negatively in May, may depend on the fact that its coelom was heavily parasitized by roundworms. It is thought that a specimen which reacted negatively in June did not respond because the dose injected was too small.

Four male specimens of *Microhyla carolinensis* did not react to the chorionic gonadotropic hormone. Two probably died because of the toxic effects of an overabundance of the hormone (50 I. U.) and for undeterminable reasons the other two did not react. As in the case with specimens of *Hyla c. cinerea,* where 100 I. U. is the critical maximum dosage, 50 I. U. may be the threshold value for *Microhyla carolinensis* since one specimen injected with that amount in April reacted positively. The critical maximum dose of chorionic

gonadotropic hormone is thought to be that dose which produces positive and negative reactions.

Secondary effects caused by the injection of chorionic gonadotropic hormone into specimens of Salientia used in this investigation were (1) changes in color of various regions of the body and (2) an interference with muscular coordination. As found in this study, the hind legs of *Rana pipiens sphenocephala* turned black when injected with the hormone. Color change produced in males of this species is thought by the writer to be reliable for indicating the presence of the chorionic gonadotropic hormone in their bodies. The color change exhibited by *Hyla c. cinerea* after injection with the hormone was a turning from a natural green to a very dark green. Some specimens turned black on their head, hind legs, and back as a result of hormone injection. The color change in this species is not reliable as an indicator of the hormone. There were detectable color changes on the bodies of the members of the other species under investigation that were neither as definable nor as frequent as those described for the above two. It is interesting to note that Bisnet (1935) reports apparent body color changes in fish following injection with a chorionic gonadotropic hormone-containing substance.

The other secondary reaction, the discordant movement of the body, produced by almost any dosage of hormone was observed in specimens of *Scaphiopus h. holbrookii, Hyla c. cinerea, Bufo t. terrestris,* and *Microhyla carolinensis.*

The mechanism of spermatozoa release in the testes of the salientia investigated was found to be as previously determined by former workers. The principal investigators, DeRobertis *et al* (1946) and Burgos and Mancini (1948), state that the release of spermatozoa is accomplished by the progressive vacuolization of the Sertoli cells and subsequent rupture of the apical ends of the cells.

A histological study of sections of testes of all injected specimens showed spermatozoa detached from the Sertoli cells and free in the lumina of the seminiferous tubules. In contrast, the sections of testes from controls showed almost all spermatozoa attached to the Sertoli cells. The lumina of the seminiferous tubules of the controls were virtually empty.

The reaction of injected *Scaphiopus h. holbrookii* to the hormone is peculiar. Even though the Sertoli cells rupture and release the

spermatozoa, sperm cells are not obtained in the urine samples.

The sections of testes indicate a seasonal spermatogenic cycle for *Scaphiopus h. holbrookii*, *Hyla c. cinerea*, and *Microhyla carolinensis*. *Bufo t. terrestris* and *Rana pipiens sphenocephala* had spermatogenesis occurring the entire period of study. Burgos and Mancini (1948) reported that in another species of Bufonidae, *Bufo arenarum*, spermatogenesis is likewise continuous.

Summary

1. Individuals of five species of Salientia, representing five families native to Florida, were injected with commercial human chorionic gonadotropic hormone during 1950. Continuing monthly collections made available males of the following forms: Pelobatidae, *Scaphiopus h. holbrookii;* Bufonidae, *Bufo t. terrestris;* Hylidae, *Hyla c. cinerea;* Ranidae, *Rana pipiens sphenocephala;* and Brevicipitidae, *Microhyla carolinensis* most months of the year.

2. The primary reaction to various doses of the chorionic gonadotropic hormone by the species of toads and frogs was the discharge of spermatozoa.

3. No male individuals of *Scaphiopus h. holbrookii* discharged spermatozoa following an injection of the hormone. Males of the other four species reacted positively.

4. Secondary reactions to the chorionic gonadotropic hormone were the changing of the skin color and neuro-muscular action that was demonstrated by kicking of the limbs and uncontrolled blinking of the eyes.

5. A histological study of the testes from a control and an injected frog of each species was made for each month in which animals were tested. Section of testes from control and injected *Scaphiopus h. holbrookii*, *Hyla c. cinerea*, and *Microhyla carolinensis* show that an annual spermatogenic cycle occurs. Continuous production of spermatozoa is characteristic of *Rana pipiens sphenocephala* and *Bufo t. terrestris*. The lumina of the seminiferous tubules of the control animals were empty, whereas those of the injected animals were filled with spermatozoa, detached from the Sertoli cells.

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A LOW TEMPERATURE SPONGE FOR DETERMINING POTASSIUM IN SOILS[1]

S. N. Edson and F. B. Smith

Despite the numerous modifications of the cobaltinitrite method for the determination of available potassium in soils, it is generally agreed that a simple technique for temperature control should be a part of the analysis before the procedure truly can be termed "a quick test for available potassium."

Other ions, such as NH_4^+, Na^+, and SO_4^-, that interfere when in quantity have been reduced to a minimum by using such additional reagents as formalin, a silver salt, and hypochlorite solutions (Snell and Snell, 1949). However, several different salts of potassium are formed, depending on the temperature of the reacting solutions, which make temperature control necessary (Feigl, 1946). To overcome this serious interference in an otherwise useful test, the temperature of the reagents must be controlled by either an ice-water bath or refrigeration (Peech and English, 1944; Hester and Shelton, 1946; Snell and Snell, 1949; Lunt, Swanson and Jacobson, 1950).

When the test is conducted at room temperature, a separate standard curve should be drawn for every 5-degree C. change (Snell and Snell, 1949). The reagents must be maintained at a temperature of 18 to 25°C. for reproducible results (Russel, 1950). In this instance, a constant temperature water bath is employed to maintain the desired conditions.

Most soil testing laboratories are not equipped with a constant temperature water bath. Consequently, a determination of available potassium in the soil very often is not made. With this thought in mind, and in view of the limitations of more cumbersome methods, a simple technique for temperature control, utilizing the low boiling point and low cost of commercial wood alcohol, is presented.

Experimental

Commercial grade methyl alcohol was selected and tested for efficiency by noting the cooling effect of a small quantity placed in

[1] Florida Agricultural Experiment Station Journal Series, No. 24.

a shallow evaporating dish. Within a few minutes the temperature of the alcohol dropped as much as 16 to 18°C. The following conditions were desired for an effective cooling system: (1) a maximum amount of surface area must be exposed to the atmosphere; (2) the material selected should act as a support for the test vials; and (3) the quantity of methyl alcohol added to the material should be sufficient to depress the temperature for a considerable period of time.

To fill these requirements, a Dupont cellulose sponge was cut to hold about 200 ml. of methanol. The final measurements of the sponge were 7 x 2 x 2 inches. Five 20 mm. holes were bored to a depth of 1¾ inches in order to accommodate five 18 x 100 mm. test vials. The sponge was enclosed on four sides with one-half inch hardware cloth and set firmly in a shallow metal catch basin.

Five test tubes, filled half full with distilled water at room temperature, were placed in the sponge and the sponge was saturated with methyl alcohol. The temperature of the water was read again after 15 minutes and the test was repeated with five other tubes half full of distilled water at room temperature (26.5-27°C.). Five such tests were made.

Finally, a test for potassium in a standard potassium chloride solution was made by the sodium cobaltinitrite turbidimetric method as follows:

A control test tube filled half full with distilled water and two empty test tubes were placed in the sponge and the sponge was saturated with 200 ml. of commercial wood alcohol. When the temperature of the water in the control tube fell to between 19 and 21°C., 2 ml. of a standard KCl solution, 0.25 ml. of the cobaltinitrite reagent, and 0.25 ml. of 37 percent formaldehyde were added to one of the empty test tubes. Two ml. of 1:1 methyl-isopropyl alcohol mixture were added to the other empty test tube. When the temperature of the test solution fell to about 20°C., the cooled methyl-isopropyl alcohol mixture was added slowly. After about one minute the tube with the test reagents was swirled to mix and replaced in the sponge for about two minutes. The amount of precipitate was determined by percent transmittance in a photometer using a red filter, *mu* 630. This amount was referred to a standard curve for ppm. of potassium.

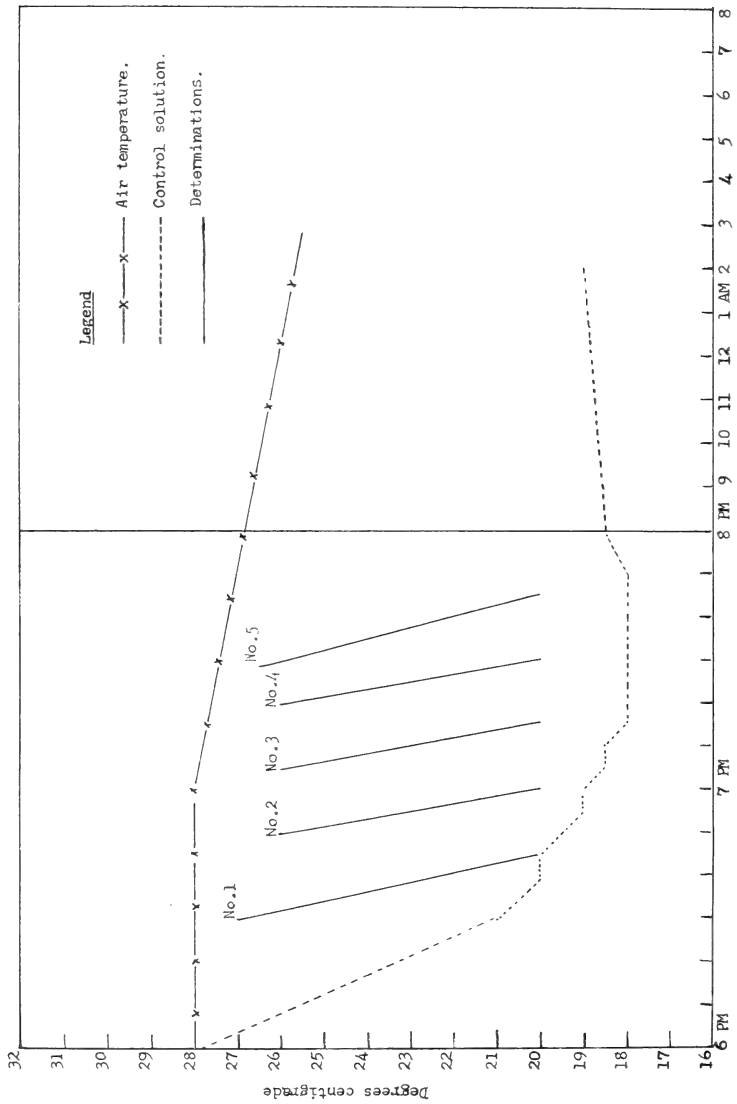

Figure 1.—The results of the temperature control experiment.

Results and Discussions

Results of the temperature control experiment are illustrated in Figure 1. For the five analyses conducted in this experiment, the average time for the temperature to fall from 27°C. was 15 minutes. This rate was fairly constant in each case. A waiting period of about 40 minutes was necessary for the sponge to lower the reading of the thermometer from a room temperature of 28 to 20°C. The temperature of the sponge remained below 19°C. for at least six hours. The sponge remained well soaked with alcohol during this time. Had the experiment been carried out in the early part of the day, the relative humidity of the air would, no doubt, have maintained a longer period of cooling, probably nearer twelve hours.

The reproducibility of the test is presented in Table I.

TABLE I

The Reproducibility of the Available Potassium Test at 19° to 21° C.

ppm. Known Solution	Determinations	ppm. Found
25	1	25.0
25	2	26.0
25	3	24.5
25	4	25.0
25	5	27.0

The data show an average error of 2 percent, with a maximum of 10 percent. This is considered fairly good agreement for a rapid test. Since the test is most effective in a well ventilated room, the possible toxic effects of the small amount of methyl alcohol fumes are negligible.

Summary

A simple procedure for controlling the temperature of the test solutions used in the determination of potassium by the cobaltinitrite method which employs the cooling effect of rapid evaporation rate of methyl alcohol was tested. It was found that the temperature of the test solution could be reduced from 27°C. to about 20°C. in 15 minutes, and this temperature was maintained for about six hours

by placing the test tube containing the solution in a sponge saturated with methyl alcohol.

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MANUSCRIPTS WANTED

The quality of the Journal and the type of articles printed are controlled, in the first place, by the manuscripts submitted to the Editor for consideration. During the past several years the receipt of manuscripts has barely kept up with our needs with the result that we have been running behind in publication and have been forced to use every available manuscript in order to go to press. The only way the Editor can give each field of interest its proportionate share of the space in the Journal is to have a surplus of manuscripts submitted.

THE EDITOR

PRESIDENT'S MESSAGE

To all members of the Florida Academy of Sciences:

First of all, allow me to express my appreciation for the great honor which you have bestowed upon me in selecting me for your president. Since its incorporation in 1936 the Florida Academy of Sciences has grown from a small group gathered in a single room at their annual meeting to hear less than a dozen papers to one of the largest and most active of the State Academies with a Bulletin which ranks among the best of the scientific journals. Much credit for this growth must go to the fine men who have preceded me as president of this organization. I will do my utmost to carry on the work of these men and thus to merit the honor of serving as president of the Florida Academy of Sciences.

Although it has been only a short time since the conclusion of the annual meeting held at the University of Tampa, we should begin now to lay the groundwork for our meeting next year on the campus of the University of Florida at Gainesville. To that end, I am hereby appointing each member of the Academy as a member of one grand planning committee to make our seventeenth annual meeting one of outstanding quality and merit. All of you who will, please write me your suggestions. Any ideas will be appreciated, but I would especially like to know what phases of the past meetings have seemed most worthwhile and which least worthwhile and how they might be improved. What innovations might be introduced at our next meeting which would be of value to those in attendance? The symposia seemed to be very well received at the Tampa meeting. If these are continued what topics do you think should be selected as subjects for future symposia and which speakers should be invited to present the different phases of these topics. Also, as a member of this committee, will you please contact prospective members among your colleagues and do what you can to interest them in the Academy. Membership application blanks may be secured from the secretary.

Let us make 1952 a banner year for the Florida Academy of Sciences.

A. M. Winchester
Stetson University
DeLand, Florida

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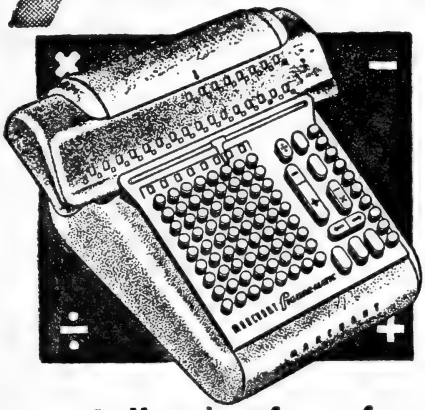

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